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DRAFT ENVIRONMENTAL IMPACT STATEMENT ON COLSTRIP
ELECTRIC GENERATING UNITS 3 & 4, 500 KILOVOLT TRANSMISSION LINES & ASSOCIATED FACILITIES

VOLUME THREE-A POWER PLANT

ENERGY PLANNING DIVISION, MONTANA STATE DEPARTMENT
OF NATURAL RESOURCES AND CONSERVATION

HELENA, MONTANA 59601

NOVEMBER, 1974

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DRAFT ENVIRONMENTAL IMPACT STATEMENT ON

THE PROPOSED MONTANA POWER COMPANY, PUGET SOUND POWER & LIGHT COMPANY, PORTLAND GENERAL ELECTRIC COMPANY, PACIFIC POWER AND LIGHT COMPANY, AND WASHINGTON WATER POWER COMPANY, COLSTRIP ELECTRIC GENERATING UNITS 3 & 4, 500 KILOVOLT KV TRANSMISSION LINES FROM COLSTRIP TO HOT SPRINGS, MONTANA, AND ASSOCIATED FACILITIES

PLEASE RETURN

ENERGY PLANNING DIVISION
ALBERT C. TSAO, ADMINISTRATOR
DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
GARY J. WICKS, DIRECTOR

NOVEMBER, 1974

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SUMMARY OF CONTENTS

Volume 1 Summary

Volume 2 Methodology, Need and Alternatives

Chapter One Introduction
Chapter Two Governmental Units Involved
Chapter Three Methodology
Chapter Four The Need for the Proposed Facility
Chapter Five Alternative Electricity Sources
Chapter Six Alternative Coal-Fired Plant Sites
Chapter Seven Power Plant System Alternatives

Volume 3A Power Plant

Chapter Eight Colstrip Project Power Plant Complex
Chapter Nine Coal Mining Activities
Chapter Ten Colstrip Site Inventory and Analysis

Volume 3B Power Plant

Chapter Eleven Colstrip Site Impact Analysis
Chapter Twelve Long-Term Impact Considerations and Information Dissemination

Glossary
Bibliography
Credits and Acknowledgements
Volume 3B Power Plant Appendixes
Volume 4 Transmission Line
Chapter One Introduction and Methodology
Chapter Two Need of the Proposed Transmission Line
Chapter Three Alternative Transmission Technology
Chapter Four Transmission Line Design Criteria and Specification Analysis
Chapter Five Study Area Inventory and Analysis
Chapter Six Study Area Impact Analysis
Chapter Seven Long-Term Impact Considerations and Information Dissemination
Glossary
Bibliography
Appendixes
Credits and Acknowledgements

Volume 3A

TABLE OF CONTENTS

Chapter Eight Colstrip Project Power Plant Complex

- 8.1 Summary of Colstrip Project
- 8.2 Construction
  - 8.2.1 Foundations and Construction Methods
  - 8.2.2 Construction Schedule and Crew Size
  - 8.2.3 Reclamation
- 8.3 Coal Content
  - 8.3.1 Analytical Data
- 8.4 Design Criteria and Functions of Major Plant Components
  - 8.4.1 Boiler
  - 8.4.2 Steam Turbine Generator
  - 8.4.3 Cooling System
  - 8.4.4 Emission Control System
    - 8.4.4.1 Stack Parameters
    - 8.4.4.2 Description of Control Efficiencies
    - 8.4.4.3 Trace Element Emission Rates
  - 8.4.5 Sludge Disposal

- 8.4.6 Water Supply and Treatment System
- 8.4.7 Fuel Handling System
- 8.5 Material Flow Diagram
  - 8.5.1 Plant Water Analysis
  - 8.5.2 Plant Air Analysis
  - 8.5.3 Plant Coal Conversion Analysis
  - 8.5.4 Plant Chemical Analysis
- 8.6 Engineering and Operating Capacity

Chapter Nine Coal Mining Activities

- 9.1 Mining Area
- 9.2 Coal Mining Requirements
  - 9.2.1 Preplanning
  - 9.2.2 Mining Method
  - 9.2.3 Alternative Means of Supplying Coal
- 9.3 Reclamation Method
  - 9.3.1 Site Preparation
  - 9.3.2 Revegetation
  - 9.3.3 Reclamation Costs
- 9.4 Associated Mining
- 9.5 Conclusion

Chapter Ten Colstrip Site Inventory and Analysis

10.1 Natural Environment
  10.1.1 Meteorology
    10.1.1.1 Climate
    10.1.1.2 Severe Weather
    10.1.1.3 Air Pollution Potential
  10.1.2 Air Quality
    10.1.2.1 Parameters to be Assessed
    10.1.2.2 Historical Data
    10.1.2.3 On-Site Sample Collection
  10.1.3 Hydrology
    10.1.3.1 Surface Water
    10.1.3.2 Ground Water
    10.1.3.3 Precipitation - Chemistry Analysis
  10.1.4 Geology
    10.1.4.1 Physiography
    10.1.4.2 Historic Setting of Study Area
    10.1.4.3 Stratigraphy
    10.1.4.4 Structure
    10.1.4.5 Economic Geology

        10.1.4.6 Seismicity

    10.1.5 Soil

    10.1.6 Vegetation

        10.1.6.1 Vegetation Types

        10.1.6.2 Relict Areas

        10.1.6.3 Forest Resource

        10.1.6.4 Range Resource

        10.1.6.5 Poisonous and Noxious Plants

        10.1.6.6 Vegetation Chemical Analysis

    10.1.7 Wildlife

        10.1.7.1 Mammals

        10.1.7.2 Birds

        10.1.7.3 Endangered Wildlife

    10.1.8 Fluoride Content in Wildlife

        10.1.8.1 Collection

        10.1.8.2 Analysis Method

        10.1.8.3 Results

        10.1.8.4 Discussion

    10.1.9 Fisheries

        10.1.9.1 Yellowstone River

10.1.9.2 Lower Yellowstone Tributaries
10.1.9.3 Reservoirs
10.1.10 Radiation
10.1.10.1 Radiactivity Content of Water
10.1.10.2 Radioactivity Content of Soil
10.1.10.3 Radioactivity Content of Vegetation
10.1.10.4 Radioactivity Content of Air
10.2 Cultural Environment
10.2.1 Existing Land Use
10.2.1.1 Land Use Categorization
10.2.2 Proposed/Potential Land Use; Land Ownership
10.2.2.1 Proposed/Potential Land Use
10.2.2.2 Land Ownership
10.2.3 Social and Economic
10.2.3.1 Population Characteristics
10.2.3.2 Social Structure
10.2.3.3 Community Services
10.2.3.4 The Structure of the Rosebud County Economy

CHAPTER EIGHT Colstrip Project - Power Plant Complex

8.1. Summary of Colstrip Project

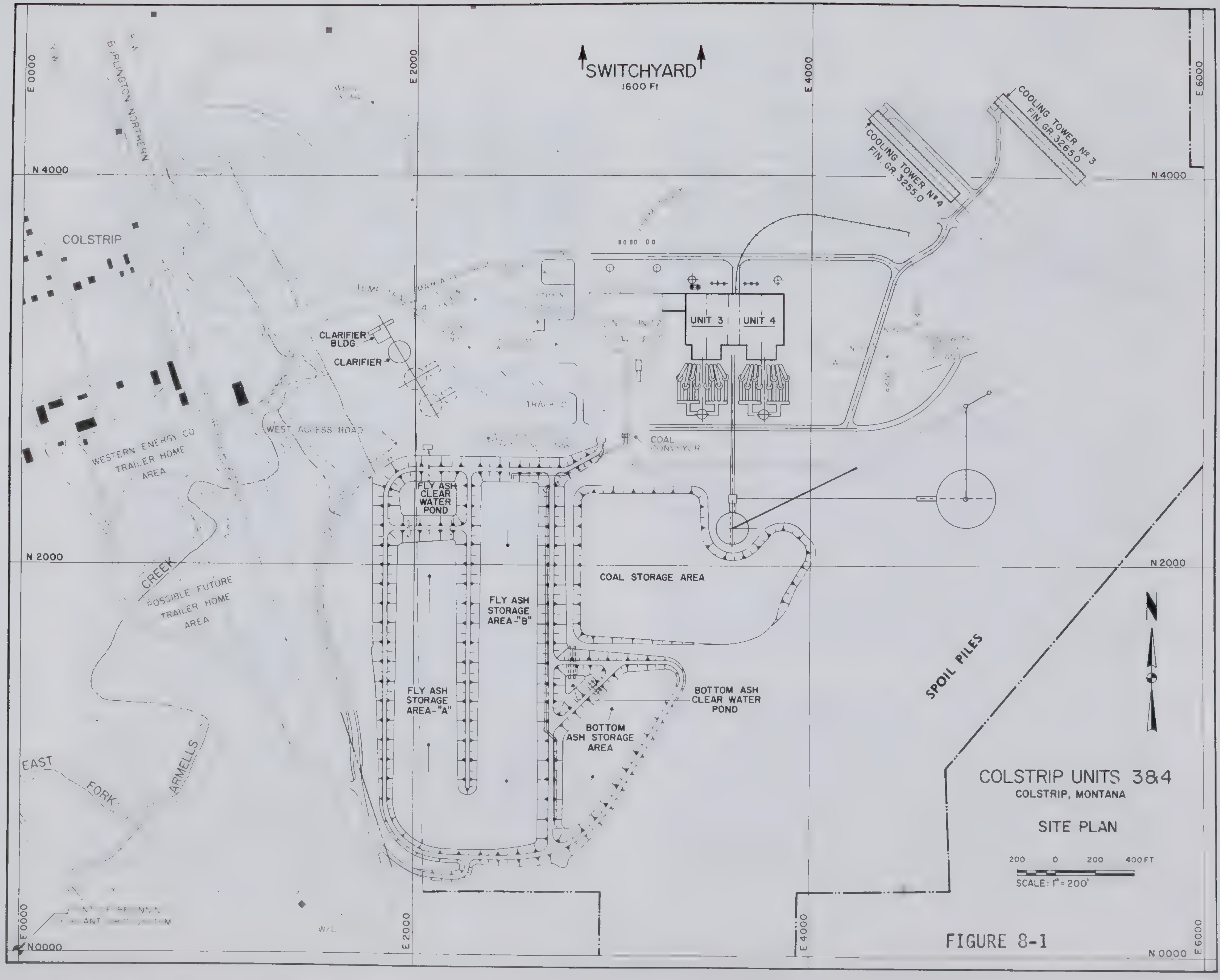
The Colstrip project as proposed by the applicants, exclusive of the transmission lines, would initially utilize some 700 acres of land. The surge pond for emergency water storage which is under construction with Units 1 and 2 will cover approximately 150 acres and the ash pond will cover approximately 350 acres. The remaining 200 acres will house the actual generating units, the switchyard (69 acres), the coal storage area (23 acres), the cooling towers, the on-site ash ponds, and other associated components and buildings for the power plant complex (see Figure 8-1 for a plot plan of the power plant site). The ash pond as proposed is sufficient for only twenty (20) years ash disposal so that at some time in the future another ash pond site must be designated to last the remaining life of the plant.

The operation of the plant, including air, water and fuel flows through the various plant facilities will first be discussed in general. Detailed discussion of each system follows in subsequent sections.

The plant water requirement, primarily make-up water to replace water evaporated by the cooling towers, is pumped from the Yellowstone River some thirty miles away. Two pipelines, one 26 inches in diameter and the other 36 inches in diameter, transport the water which is pumped by three, 4000 horsepower motor driven pumps. The water is either routed to the surge pond for storage or by-passes the surge pond to go directly to the four units. Each unit has a separate cooling tower and cooling water supply system. The make-up water to all of these systems will be about 50 cfs of the total 59 cfs maximum water flow into the plant. The cooling water enters the condenser where it picks up heat from the low pressure steam which is being condensed. Upon leaving the condenser, the hot cooling water is pumped to the cooling towers where it is cooled by partial evaporation. The cooled water leaving the towers is then ready to mix with the make-up water and go back through the condenser again.

Part of the water which does not go to the cooling system is used for boiler make-up water. This water is very highly demineralized and becomes part of the closed boiler system. The water is heated by the flame in the boiler to produce steam of 1000°F and 2400 pounds per square inch (psi). This steam is piped to the turbine where it is expanded through the turbine and gives up it's energy to rotate the generator shaft and produce electricity. After the steam is expanded through the last stage of the low pressure turbine it is passed down into the condenser where it is condensed by the cooling water. The condensate is then routed through a series of heaters and finally returns to the boiler for further heating and conversion back into steam.

The coal is mined in nearby strip mines, delivered to the site by truck, and dumped in the unloading area in large pieces. This coal is conveyed by belt to the crusher where it is crushed to sizes of approximately 1.5 inches or smaller. From there the coal is conveyed to the coal storage area where is is piled until used.



COLSTRIP UNITS 3&4
COLSTRIP, MONTANA

SITE PLAN

FIGURE 8-1

PLEASE RETURN

Usually a 90-day supply of coal is piled in the storage area. As it is needed, the coal is mechanically fed into reclaim hoppers and then again conveyed by belt into coal bunkers directly above the pulverizers. The coal is fed from the bunkers down through feeders which control the flow and then into the pulverizers where it is pulverized into very fine particles. This coal dust is then transported by air flow up to the burner locations in the four corners of the boiler and mixed with combustion air from the wind box. The coal-air mixture is then blown into the center of the boiler where a very intense, swirling fireball sustains the combustion process. At full load Units 3 and 4 as proposed would each consume coal from mining area "C" at a rate of about 10,800 tons per day. This rate of combustion would release approximately 7,573 million BTU per hour of heat, 16,080 lb. per hour of SO_2 and 91,783 lb. per hour of ash in the boilers. Approximately 18,356 lb. per hour of ash would be collected in the boiler and economizer hoppers.

As the coal burns in the center of the boiler the heavier particles of combustion and clinkers fall to the bottom or the throat of the boiler. From there they drop into the bottom ash hopper. This hopper is full of water which cools the clinkers and transports them to clinker grinders. After grinding, the bottom ash-water mixture is pumped to the ash ponds where the ash settles out and the water is decanted back through the system. The lighter particles or fly ash and combustion gases are routed up through the boiler superheat and reheat areas, down through the economizer and air preheaters and then to the wet venturi scrubbers. The manufacturer and the applicants believe that the proposed scrubbers will limit SO_2 emissions to 1.0 pound per million BTU input. The removal efficiency necessary for this emission rate is shown in Section 8.4.4.2. It is also believed that the scrubbers will remove at least 99.5% of the particulates. The gas is then reheated to 175°F and exhausted through induced draft fans to the stacks and then to the atmosphere.

8.2. Construction

8.2.1. Foundations and Construction Methods

The ground beneath the turbine building, boiler, pollution control equipment, chimney and cooling tower for both Units 3 and 4 would be excavated to a depth of about 30 feet to remove a coal seam about 10 feet thick. The excavated area for both units is approximately 700 feet by 300 feet in plan and would be back-filled with the excavated material and additional material from local mine spoil. These materials would be compacted to about six feet below plant grade. After construction of grade beams and installation of buried piping outside the plant proper, the yard area would be built up to final plant grade with compacted backfill.

All foundations, ground floor slabs and structures below grade would be of reinforced concrete construction. Foundations for the boiler, turbine generator building, the turbine generator pedestal and silos would consist of caissons about 35 feet deep. Major equipment in the turbine building and boiler areas such as the forced draft (FD) fans, boiler feed booster pumps and coal mills would be on similar caissons. Ground floor equipment such as load centers and small pumps within the buildings would be supported on a structural floor slab which, in turn, would be supported by grade beams and caissons. The chimney, transformers, air pollution control system, induced draft (ID) fans, and all other major structures within the excavated area would be supported on caissons. Minor structures where settlement is not a problem would be supported on spread footings. The cooling towers would be supported on compacted backfill, after removal of the underlying coal.

As each foundation system is completed, related structural steel would be raised and equipment, piping, siding, wiring, etc. installed. The sequence is depicted on the Milestone Summary Schedule shown in Figure 8-2.

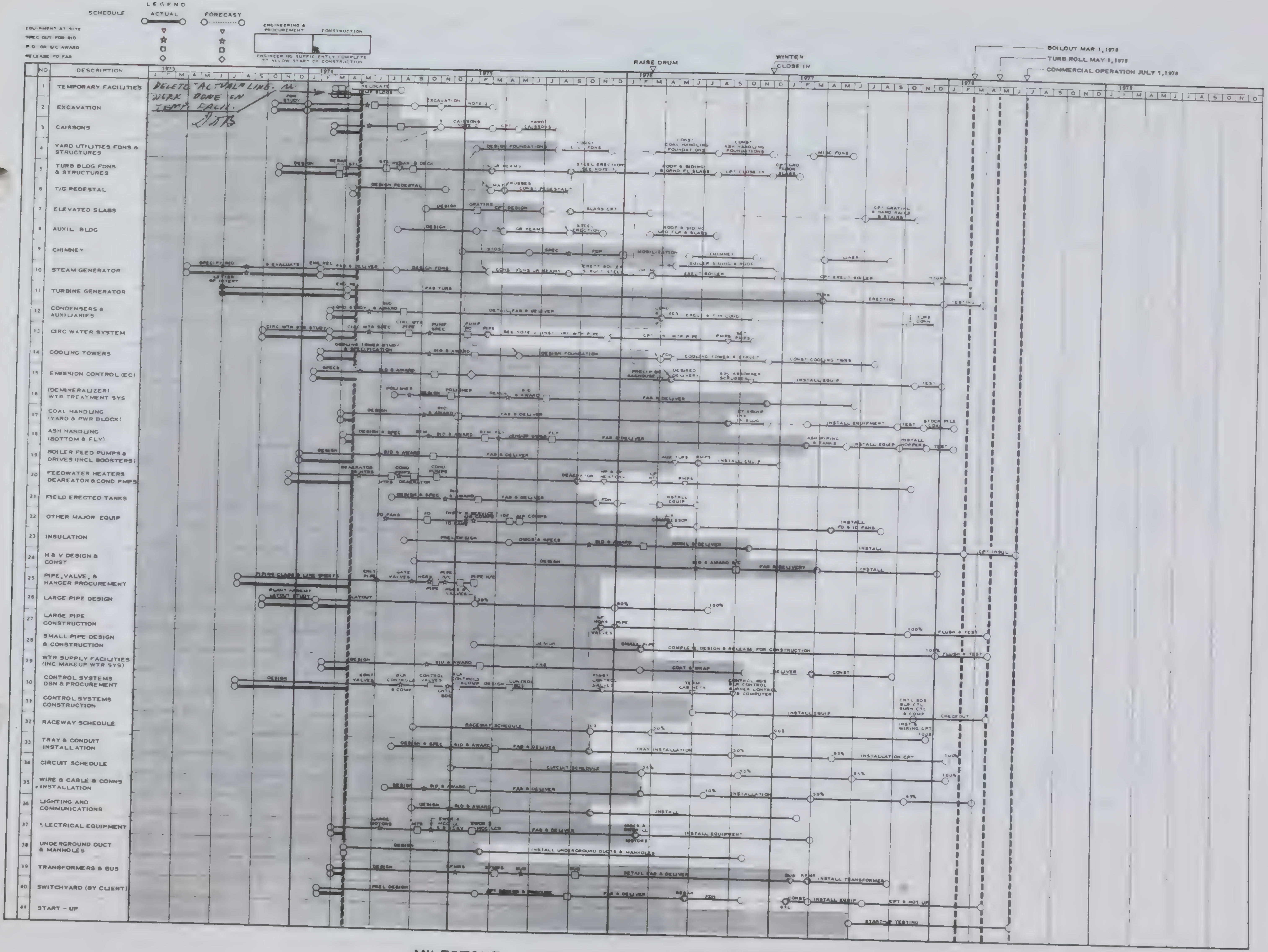
Equipment includes trucks, cars, bulldozers, scrapers, shovels, cranes, graders, rollers, caissons, drilling rigs, welders, air compressors, and other conventional construction equipment. The design and construction schedule have not advanced sufficiently to permit estimating the quantities of each item of equipment that would be on the site at any given time.

8.2.2. Construction Schedule and Crew Size

The best available information concerning construction schedules for Units 3 and 4 is presented in the Milestone Summary Schedule (Fig. 8-2). This schedule was prepared for MPC by Bechtel Corporation. It is actually for Unit 3 with the schedule for Unit 4 being the same only one year later. The crew size can be found in Figures 8-3 through 8-12. These figures assume a November 1, 1974 starting date for actual construction. It should be noted that if Units 3 and 4 are approved, the starting date for construction will be sometime during 1975. Therefore, if the same completion date is maintained the various crew size estimates must be increased in Figures 8-3 through 8-12. If, however, the completion dates are moved ahead a length of time corresponding to that of the starting dates, the crew size estimates may be valid. The figures contain total manual and non-manual personnel data for the construction of Units 3 and 4 on a monthly basis. The term "non-manual personnel" refers to supervisory, clerical, engineering, etc., personnel, while the term "manual personnel" means craft laborers. The figures also give data for crew sizes of each manual craft on the same monthly basis. By referring to the Milestone Summary Schedule, the date for a given activity may be determined. Then by using that date and referring to the crew size curves of Figures 8-3 through 8-12, an estimate can be obtained of how many workers will be on the site at a given time and what their skills are. A description of the various crafts shown in the figures follows (U.S. Dept. of Labor 1965):

1) Boilermakers

> Assembles, analyzes defects in, and repairs boilers, pressure vessels, tanks, and vats in the field, following blueprints and using handtools and power tools: Locates and marks

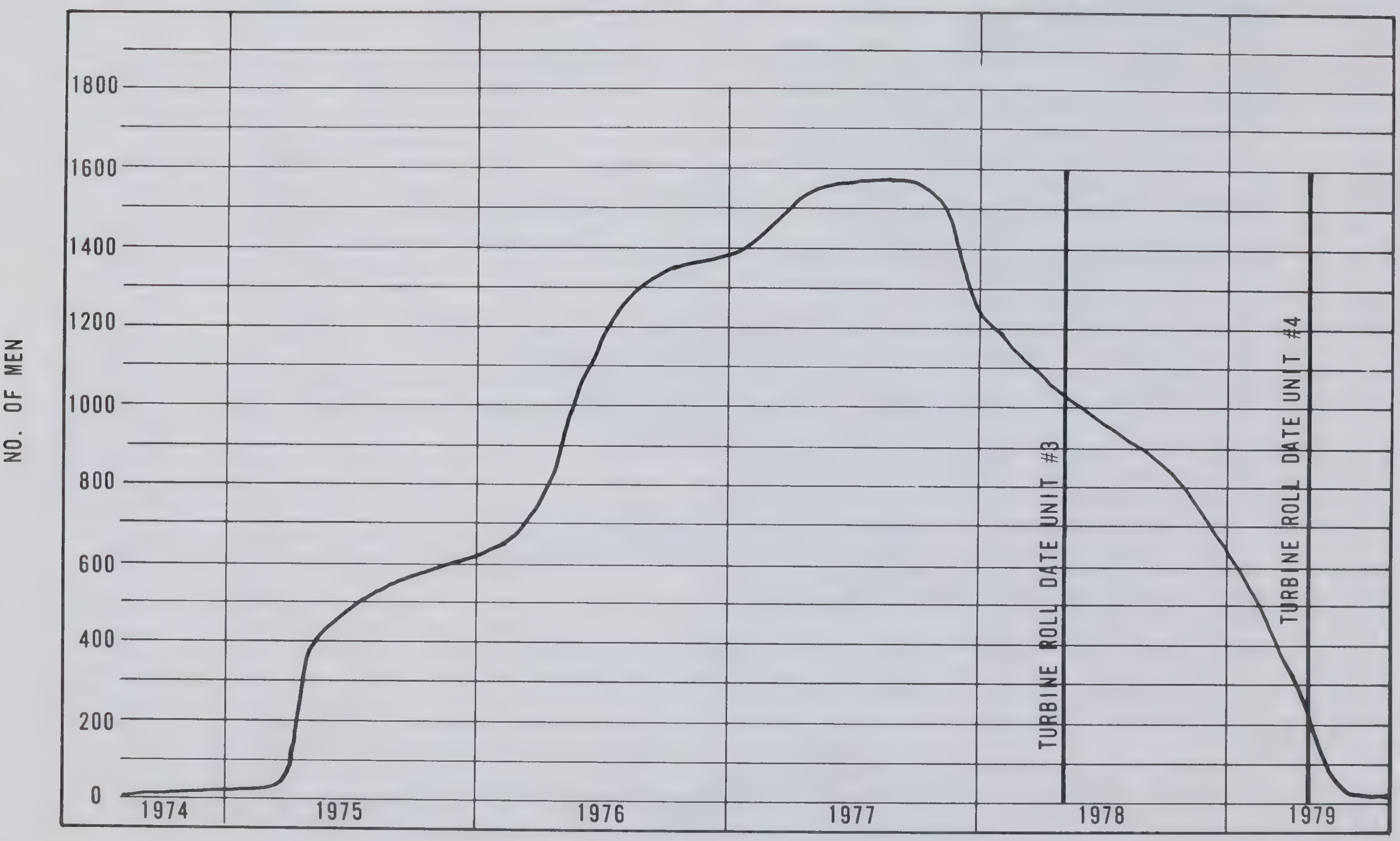


DELETE "ACTUAL" LINE. NO WORK DONE ON TEMP. FACIL.

MILESTONE SUMMARY SCHEDULE FOR COLSTRIP # 3

FIGURE 8-2

NOTES: 1. CURVE INCLUDES: A. BECHTEL & SUBCONTRACT MANUAL & NONMANUAL PERSONNEL. B. DISTRIBUTABLE MANHOURS. 2. CURVE EXCLUDES: CONTINGENCY MANHOURS. 3. BASED ON SEPT. 1, 1974 START OF RELOCATING TEMPORARY FACILITIES AND A NOV. 1, 1974 START OF EXCAVATION FOR UNITS 3 & 4.

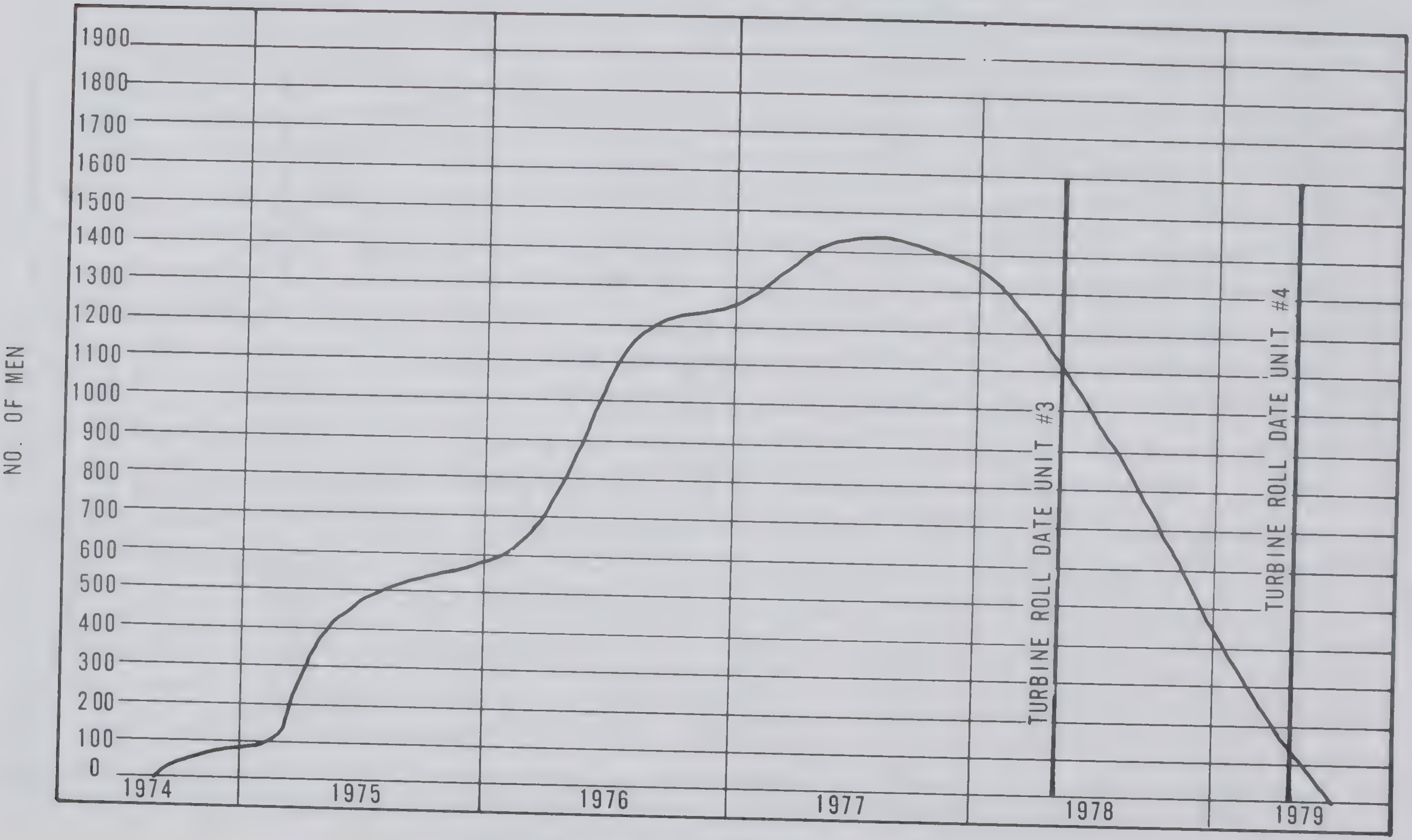


MANPOWER LOADING FORECAST

TOTAL MANUAL & NONMANUAL PERSONNEL

FIGURE 8-3

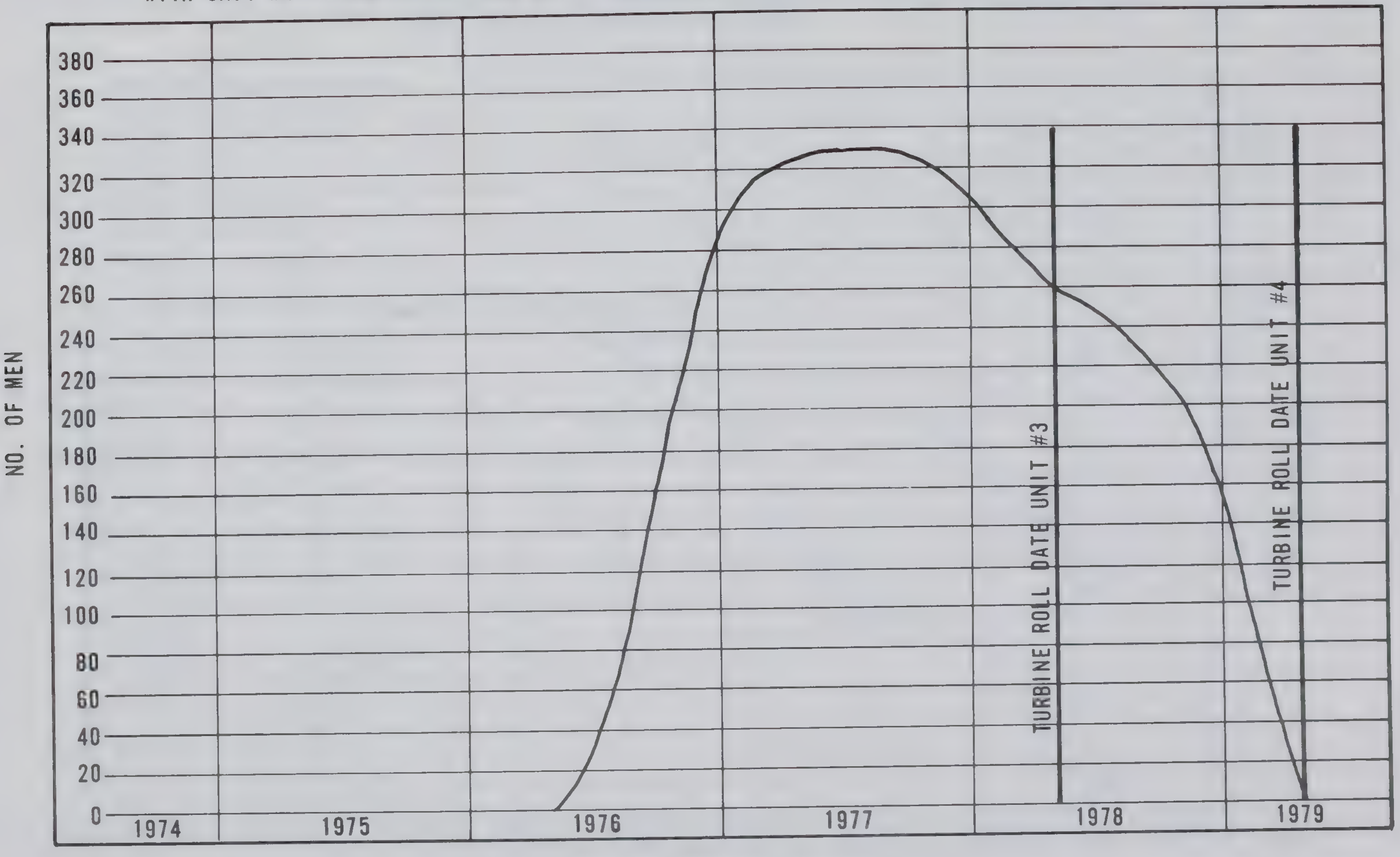
NOTES: 1. CURVE DOES NOT INCLUDE CONTINGENCY. 2. CURVE INCLUDES DISTRIBUTABLE MANHOURS. 3. BASED ON M.H. FOR UNITS 3 & 4 ONLY. 4. SCHEDULE BASIS: REV. #0 OF UNIT #3 MILESTONE SUMMARY SCHEDULE WITH UNIT #4 1 YEAR LATER THAN UNIT #3 SCHEDULE.



MANPOWER LOADING FORECAST
TOTAL MANUAL PERSONNEL

FIGURE 8-4

NOTES: 1. CURVE DOES NOT INCLUDE CONTINGENCY. 2. CURVE INCLUDES DISTRIBUTABLE MANHOURS. 3. BASED ON M.H. FOR UNITS 3 & 4 ONLY. 4. SCHEDULE BASIS: REV. #0 OF UNIT #3 MILESTONE SUMMARY SCHEDULE WITH UNIT #4 1 YEAR LATER THAN UNIT #3 SCHEDULE.

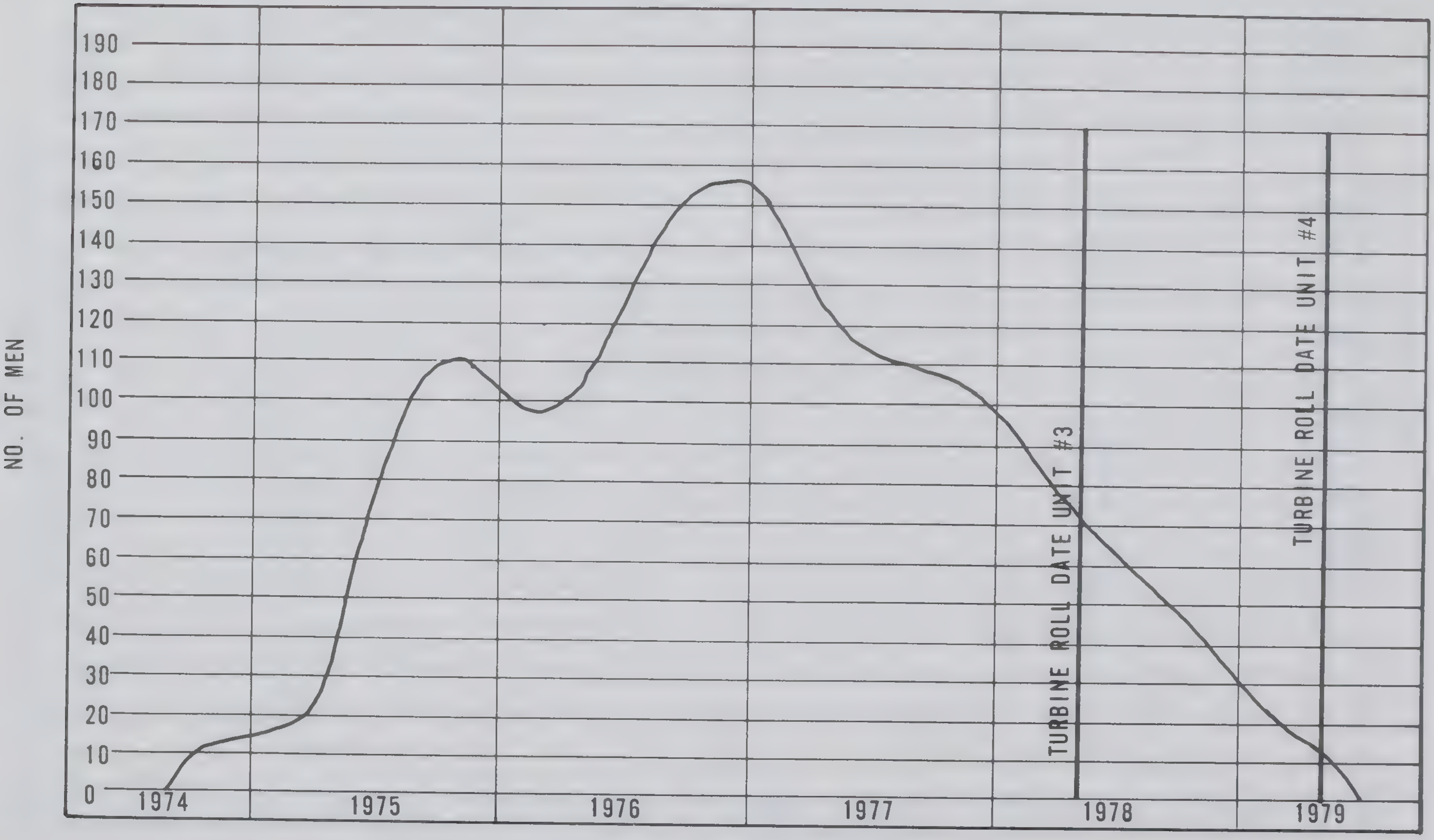


MANPOWER LOADING FORECAST

BOILERMAKERS

FIGURE 8-5

NOTES: 1. CURVE DOES NOT INCLUDE CONTINGENCY. 2. CURVE INCLUDES DISTRIBUTABLE MANHOURS. 3. BASED ON M.H. FOR UNITS 3 & 4 ONLY. 4. SCHEDULE BASIS: REV. #0 OF UNIT #3 MILESTONE SUMMARY SCHEDULE WITH UNIT #4 1 YEAR LATER THAN UNIT #3 SCHEDULE.

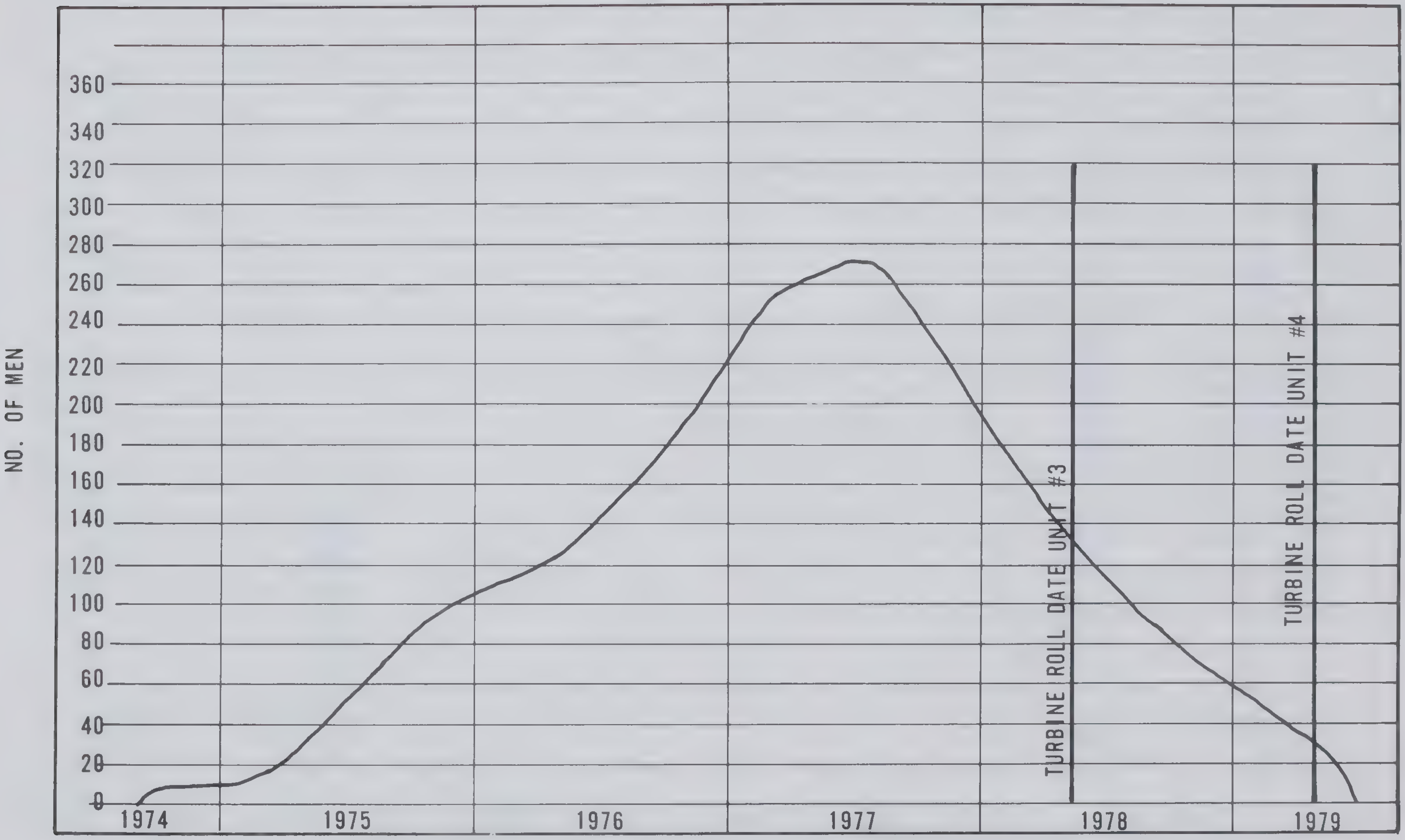


MANPOWER LOADING FORECAST

CARPENTERS

FIGURE 8-6

NOTES: 1. CURVE DOES NOT INCLUDE CONTINGENCY. 2. CURVE INCLUDES DISTRIBUTABLE MANHOURS. 3. BASED ON M.H. FOR UNITS 3 & 4 ONLY. 4. SCHEDULE BASIS: REV. #0 OF UNIT #3 MILESTONE SUMMARY SCHEDULE WITH UNIT #4 1 YEAR LATER THAN UNIT #3 SCHEDULE.

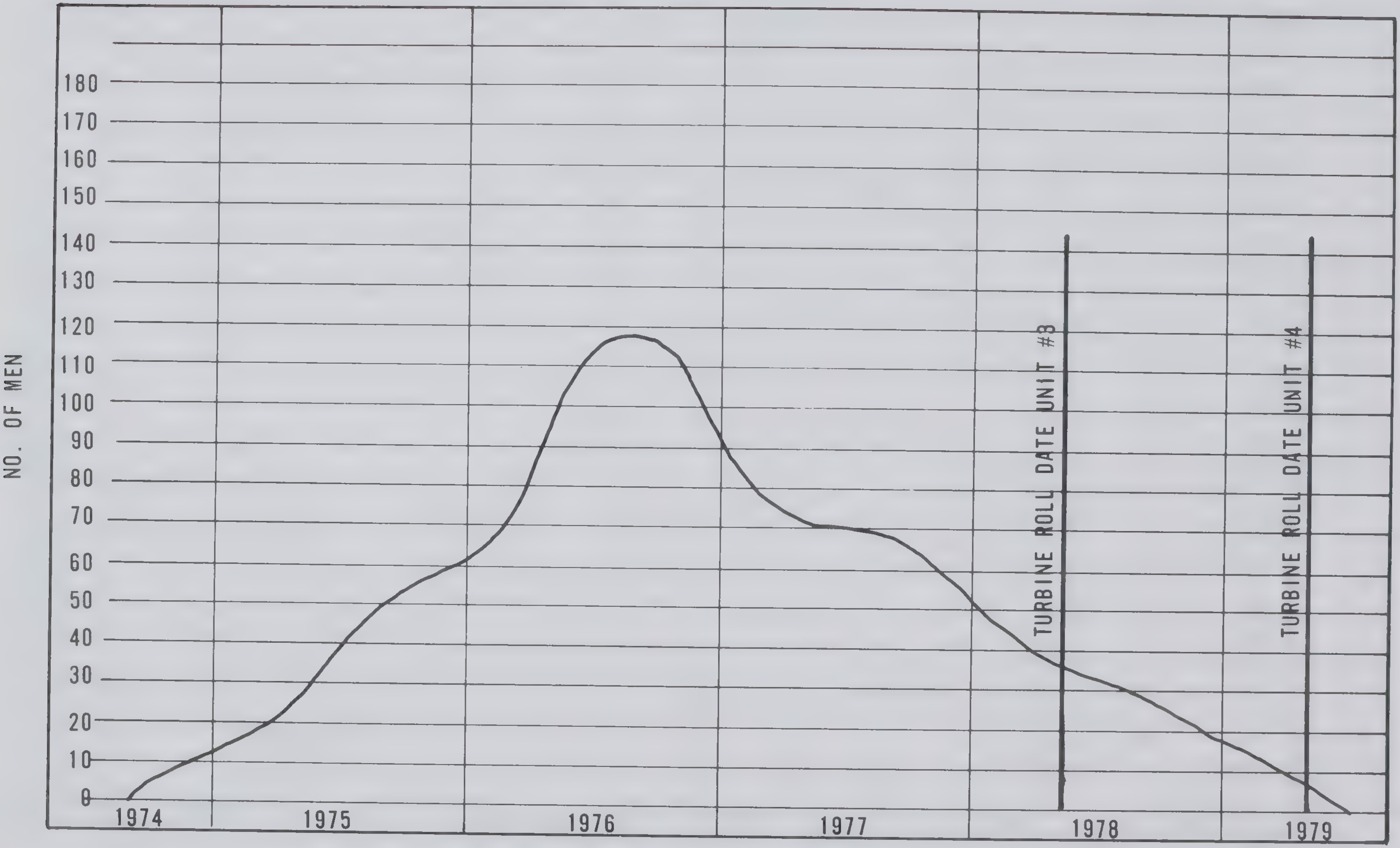


MANPOWER LOADING FORECAST

ELECTRICIANS

FIGURE 8-7

NOTES: 1. CURVE DOES NOT INCLUDE CONTINGENCY. 2. CURVE INCLUDES DISTRIBUTABLE MANHOURS. 3. BASED ON M.H. FOR UNITS 3 & 4 ONLY. 4. SCHEDULE BASIS: REV. #0 OF UNIT #3 MILESTONE SUMMARY SCHEDULE WITH UNIT #4 1 YEAR LATER THAN UNIT #3 SCHEDULE.

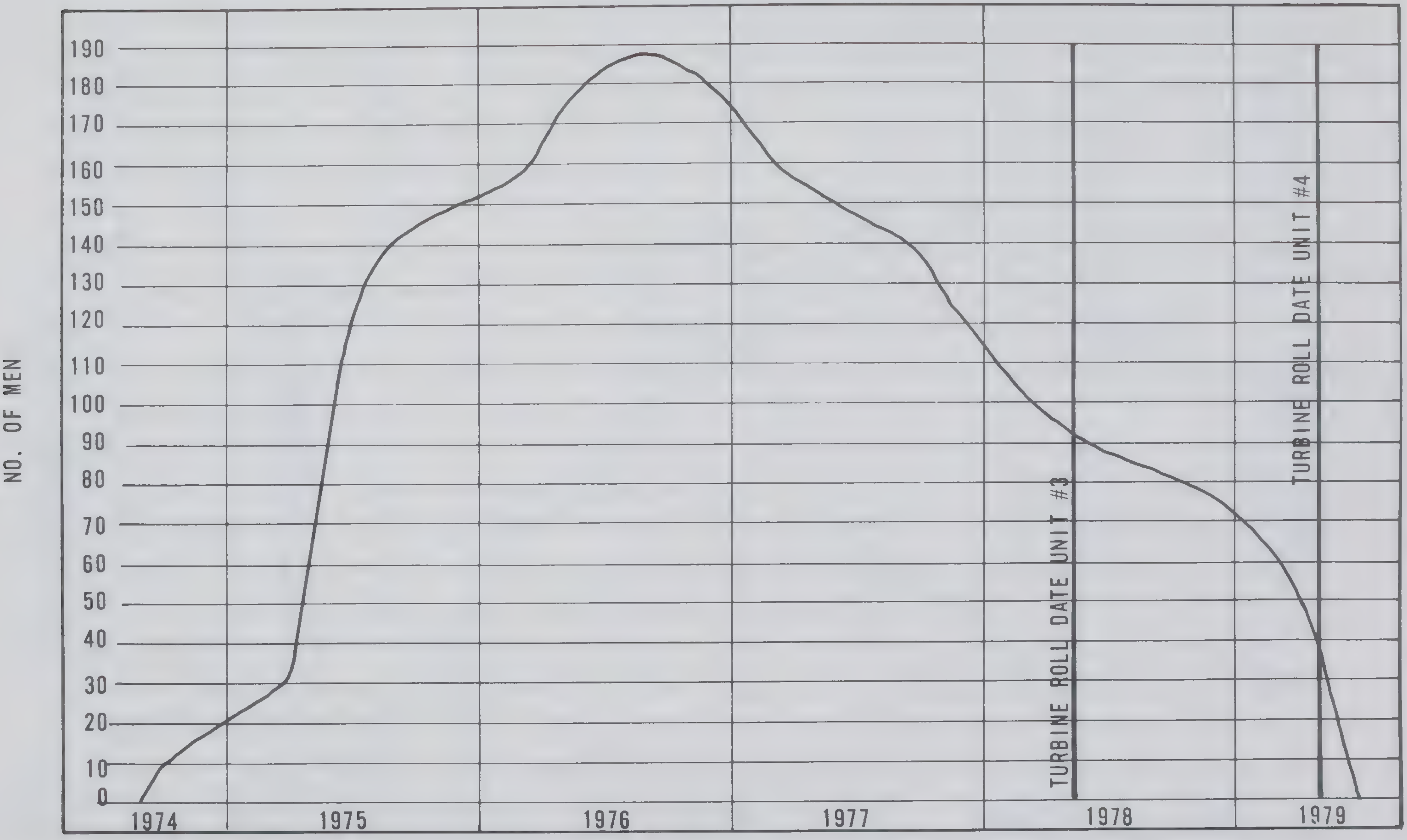


MANPOWER LOADING FORECAST

IRONWORKERS

FIGURE 8-8

NOTES: 1. CURVE DOES NOT INCLUDE CONTINGENCY. 2. CURVE INCLUDES DISTRIBUTABLE MANHOURS. 3. BASED ON M.H. FOR UNITS 3 & 4 ONLY. 4. SCHEDULE BASIS: REV. #0 OF UNIT #3 MILESTONE SUMMARY SCHEDULE WITH UNIT #4 1 YEAR LATER THAN UNIT #3 SCHEDULE.

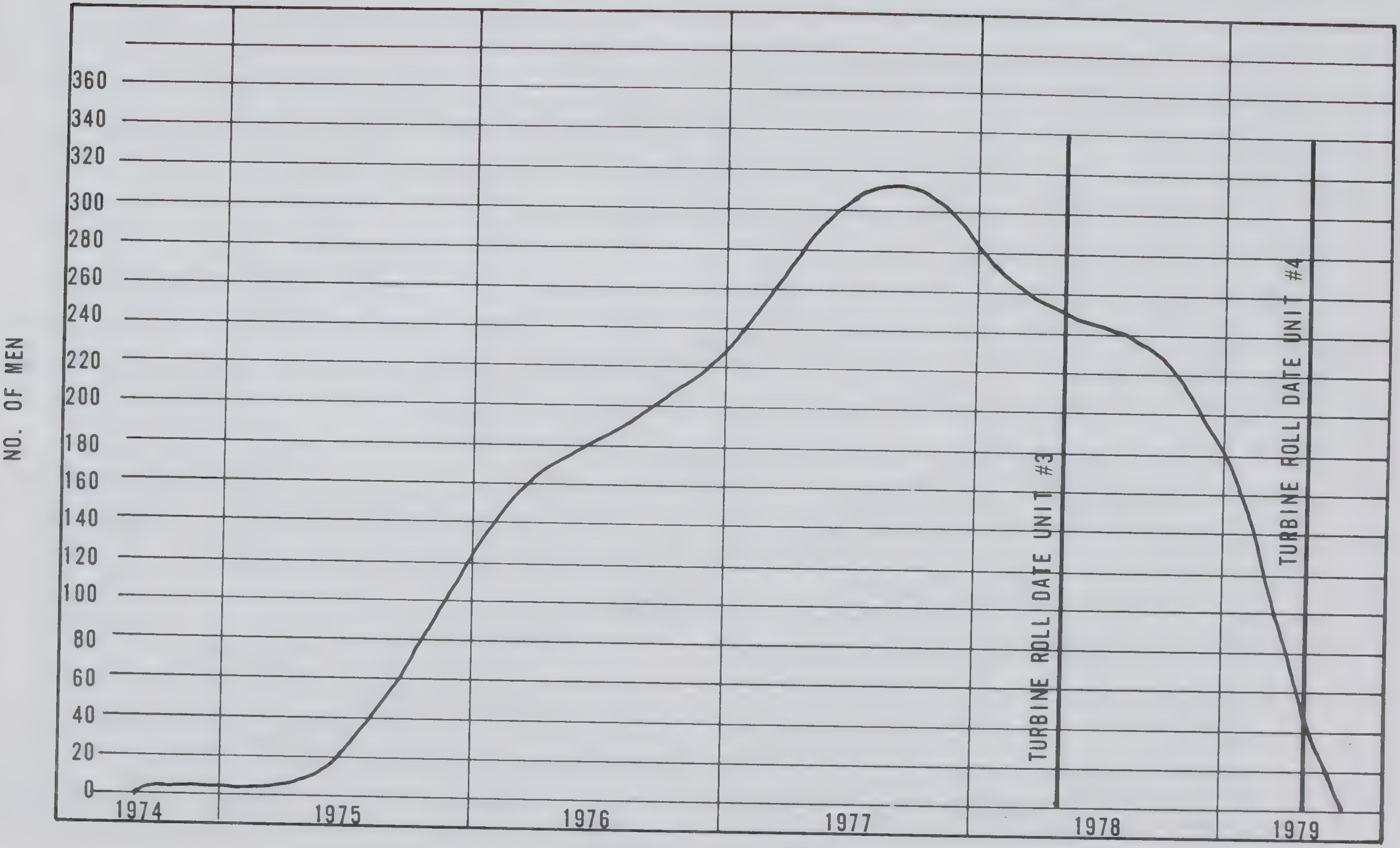


MANPOWER LOADING FORECAST

LABORERS

FIGURE 8-9

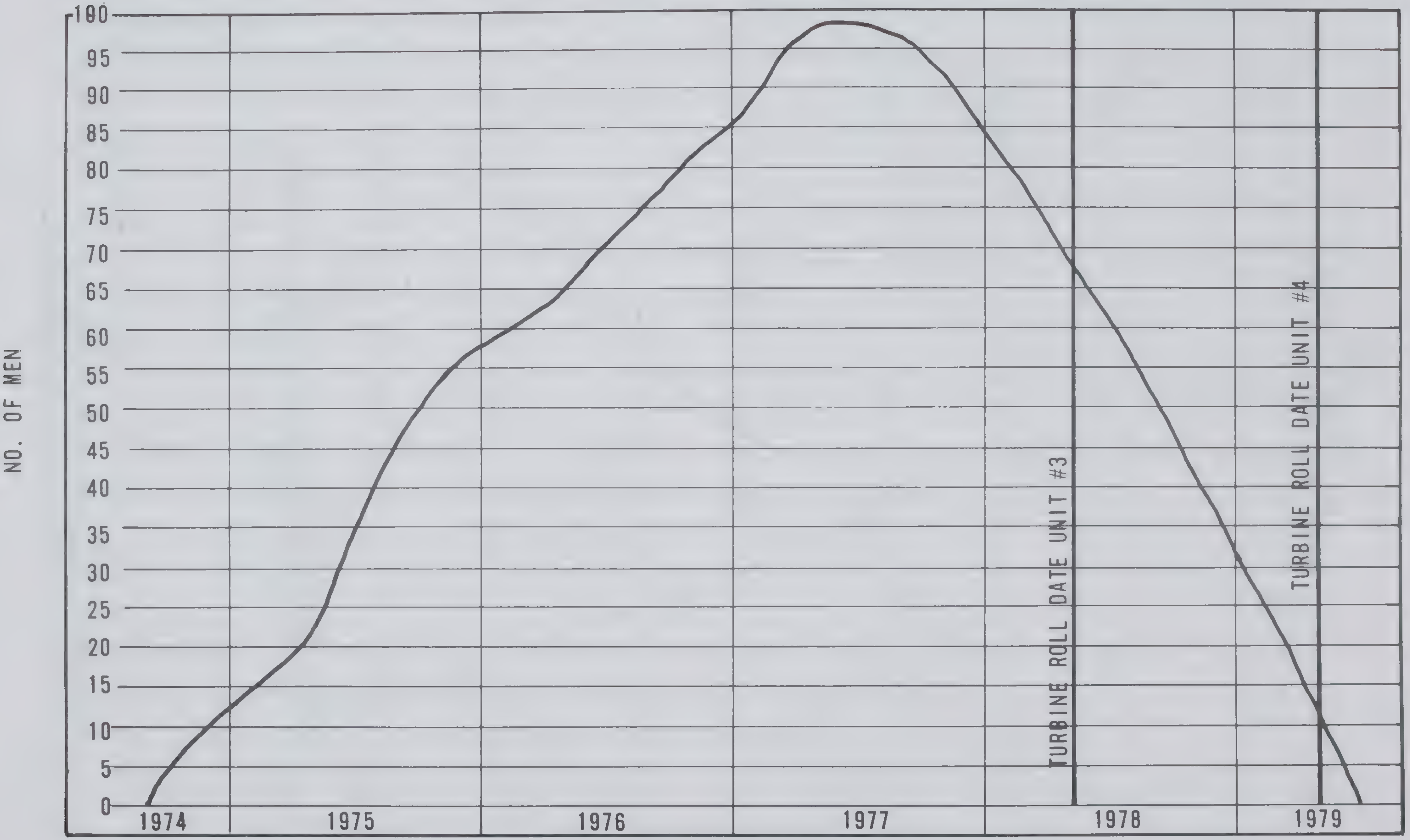
NOTES: 1. CURVE DOES NOT INCLUDE CONTINGENCY. 2. CURVE INCLUDES DISTRIBUTABLE MANHOURS. 3. BASED ON M.H. FOR UNITS 3 & 4 ONLY. 4. SCHEDULE BASIS: REV. #0 OF UNIT #3 MILESTONE SUMMARY SCHEDULE WITH UNIT #4 1 YEAR LATER THAN UNIT #3 SCHEDULE.



MANPOWER LOADING FORECAST
PIPE FITTERS

FIGURE 8-10

NOTES: 1. CURVE DOES NOT INCLUDE CONTINGENCY. 2. CURVE INCLUDES DISTRIBUTABLE MANHOURS. 3. BASED ON M.H. FOR UNITS 3 & 4 ONLY. 4. SCHEDULE BASIS: REV. #0 OF UNIT #3 MILESTONE SUMMARY SCHEDULE WITH UNIT #4 1 YEAR LATER THAN UNIT #3 SCHEDULE.

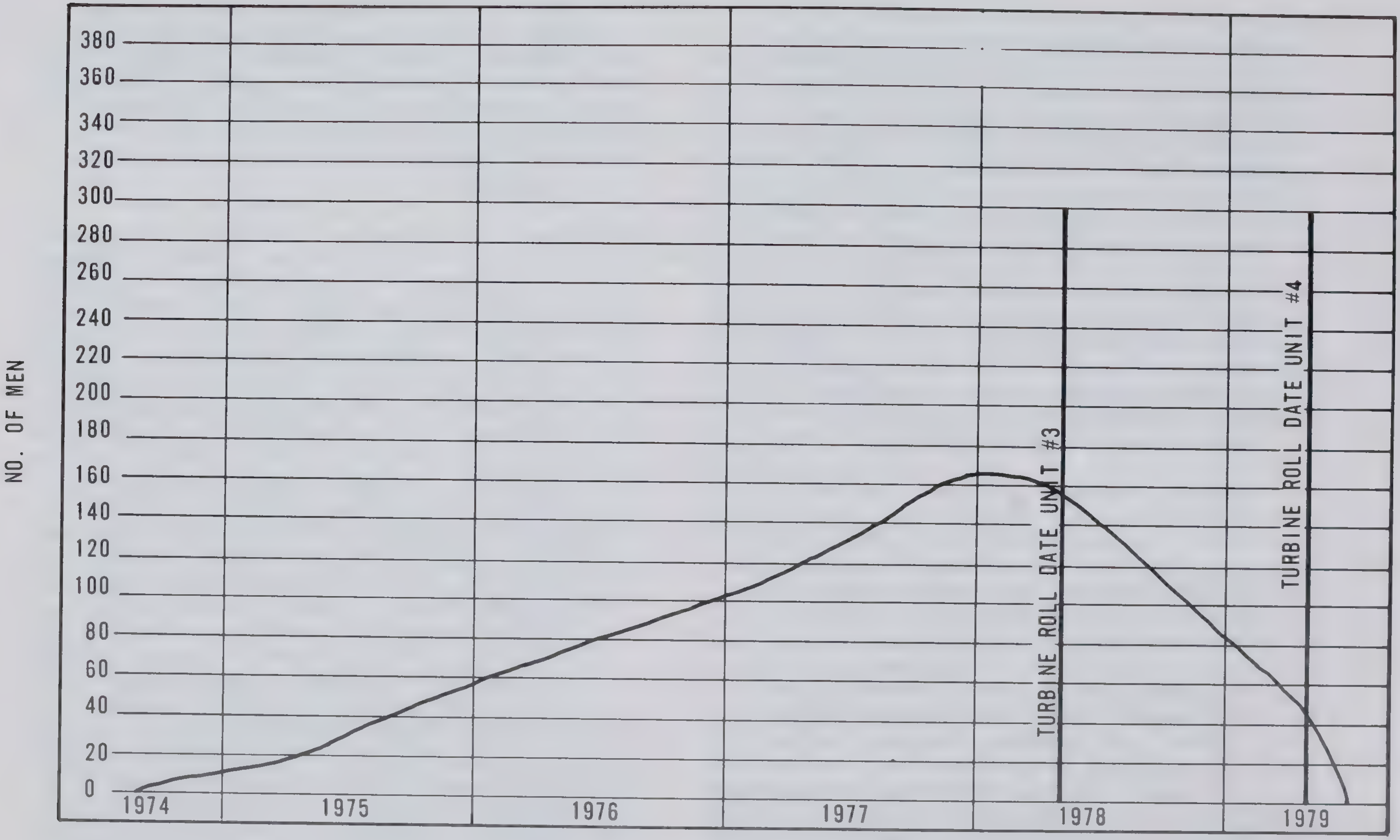


MANPOWER LOADING FORECAST

OPERATING ENGINEERS

FIGURE 8-11

NOTES: 1. CURVE DOES NOT INCLUDE CONTINGENCY. 2. CURVE INCLUDES DISTRIBUTABLE MANHOURS. 3. BASED ON M.H. FOR UNITS 3 & 4 ONLY. 4. SCHEDULE BASIS: REV. #0 OF UNIT #3 MILESTONE SUMMARY SCHEDULE WITH UNIT #4 1 YEAR LATER THAN UNIT #3 SCHEDULE.



MANPOWER LOADING FORECAST

OTHER CRAFTS

FIGURE 8-12

reference points for columns or plates on foundation, using master straightedge, squares, transit, and measuring tape, and applying knowledge of geometry. Sets up rigging or signals crane operator to lift parts to specified position. Alines structures or plate sections to assemble boiler frame, tanks, or vats, using plumb bobs, levels, wedges, dogs, or turnbuckles. Hammers, flame-cuts, files, or grinds irregular sections or structures to fit edges together. Bolts or arc-welds structures and sections together. Positions drums and headers into supports which are bolted or welded to frame. Alines water tubes and connects and expands ends to drums and headers, using tube expander. Bells, beads with power hammer, or welds tube ends to insure leakproof joints. Bolts or welds casing sections, uptakes, stacks, baffles, and such fabricated parts as chutes, air heaters, fan stands, feeding tube, catwalks, ladders, coal hoppers, and safety hatch to frame. Installs manholes, handholes, valves, gages, and feedwater connection in drums to complete assembly of water tube boilers. Assists in testing assembled vessels by pumping water or gas under specified pressure into vessel and observing instruments for evidence of leakage. Repairs boilers or tanks in field by unbolting or flame cutting defective sections or tubes, straightening plates with torch or jacks, installing new tubes, fitting and welding new sections and replacing worn lugs on bolts. May rivet and calk sections of vessels, using pneumatic riveting and calking hammers. May line firebox with refractory brick and asbestos rope and blocks [BRICKLAYER, REFRACTORY BRICK (any ind.)]. May fabricate such parts as stacks, uptakes, and chutes to adapt boiler to premises in which it is installed [BOILERMAKER II]. Distinguish from BOILERMAKER MECHANIC, who assembles only.

2) Carpenters

Constructs, erects, installs, and repairs structures and fixtures of wood, plywood, and wallboard, using carpenter's handtools and power tools, and conforming to local building codes; Studies blueprints, sketches, or building plans, for information pertaining to type of material required, such as lumber or fiberboard, and dimensions of structure or fixture to be fabricated. Selects specified type of lumber or other materials. Prepares layout, using rule, framing square, and calipers. Marks cutting and assembly lines on materials, using pencil, chalk, and marking gage. Shapes materials to prescribed measurements, using saws, chisels, and planes. Assembles cut and shaped materials and fastens them together with nails, dowel pins, or glue. Verifies trueness of structure with plumb bob and carpenter's level. Erects framework for structures and lays subflooring. Builds stairs and lays out and installs partitions and cabinet work. Covers subfloor with building paper to keep out moisture and lays hardwood, parquet, and wood-strip-block floors by nailing floors to subfloor or cementing them to mastic or asphalt base. Applies shock-absorbing, sound-deadening, and decorative paneling to ceilings and walls. Fits and installs prefabricated window frames, doors, doorframes, weather stripping, interior and exterior trim, and finish hardware, such as locks, letter drops, and kick plates. Constructs concrete forms and pouring chutes. Erects scaffolding and ladders for assembling structures above ground level. May weld metal parts to steel structural members.

3) Electricians

wireman. Plans layout and installs and repairs wiring, electrical fixtures, apparatus, and control equipment: Plans new or modified installations to minimize waste of materials, provide access for future maintenance, and avoid unsightly, hazardous, and unreliable wiring, consistent with specifications and local electrical code. Prepares sketches showing location of all wiring and equipment or follows diagrams or blueprints prepared by others, insuring that concealed wiring is installed before completion of future walls, ceilings, and flooring. Measures, cuts, bends, threads, assembles, and installs electrical conduit, using such tools as hacksaw, pipe threader, and conduit bender. Pulls wiring through conduit, assisted by ELECTRICIAN HELPER. Splices wires by stripping insulation from terminal leads with knife or pliers, twisting or soldering wires together, and applying tape or terminal caps. Connects wiring to lighting fixtures and power equipment, using handtools. Installs control and distribution apparatus, such as switches, relays, and circuit-breaker panels, fastening them in place with screws or bolts, using drills, masonry chisels, hammer, anchor bolts, and wrench. Connects power cables to equipment, such as electric range or motor, and installs grounding leads. Tests continuity of circuit to insure electrical compatibility and safety of all components, using standard instruments, such as ohmmeter, battery, and buzzer and oscilloscope. Observes functioning of installed equipment or system to detect hazards and need for adjustments, relocation, or replacement. May repair faulty equipment or systems [ELECTRICAL REPAIRMAN]. May be required to hold license. May cut and weld steel structural members, using flame-cutting and welding equipment. May be designated according to work location as MINE ELECTRICIAN (mining & quarrying).

4) Ironworkers

STRUCTURAL-STEEL WORKER
bridgeman; housesmith; iron erector; ironworker; steel erector; structural-iron erector; structural-iron worker; structural-steel erector. Performs any combination of the following duties to raise, place, and unite girders, columns, and other structural-steel members to form completed structures or structure frameworks, working as a member of a crew: Sets up hoisting equipment for raising and placing members. Fastens steel members to cable of hoist, using chain, cable, or rope. Signals worker operating hoisting equipment to lift and place steel member. Guides member with tag line (rope) or rides on member to guide it as it is hoisted into position. Pulls, pushes, or

pries members into approximate position while they are supported by hoisting device. Forces members into final position, using turnbuckles, crowbars, jacks, and handtools. Alines rivet holes in member being placed with corresponding holes in previously placed member by driving drift pins or handle of wrench through holes. Verifies vertical and horizontal alinement of members with plumb bob and level. Bolts alined members to keep them in position until they can be permanently riveted, bolted, or welded in place. Catches hot rivets tossed by RIVET HEATER (any ind.) in bucket and inserts them in rivet holes, using tongs. Bucks up (holds) rivets while RIVETER, PNEUMATIC (any ind.) uses airhammer to form heads on rivets. Cuts and welds steel members to make alterations, using oxyacetylene welding equipment. May specialize in erecting or repairing specific types of structures and be designated accordingly as BRIDGE-MAINTENANCE MAN; CHIMNEY BUILDER, REINFORCED CONCRETE; SCAFFOLD BUILDER, METAL; STRUCTURAL-STEEL-EUIPMENT ERECTOR.

5) Laborers

LABORER, GENERAL
----(iron & steel). Performs any combination of tasks to assist workers engaged in production of iron and steel: Feeds and offbears equipment, such as conveyors, pilers, and loaders, to charge furnaces, transport hot metal to rollers, and store finished products. Bundles and ties metal rods, sheets, and wire, using banding machine and handtools. Attaches cranehooks, slings, or cradles to material for moving by ELECTRIC-BRIDGE-OR-GANTRY-CRANE OPERATOR (any ind.). Transports material to and from production stations, using handtruck. Feeds material, such as ganister, magnesite, and limestone into crushers to prepare additives for molten metal. Grinds defects, such as burrs, seams, and scratches, from rolled steel, using portable grinder. Sweeps scale from work area and empties dust bins, using wheelbarrow, broom, and shovel. Breaks up manganese and scrap metal to facilitate handling, using sledge and pneumatic hammer. Marks identification numbers on steel billets, using chalk. Verifies dimension of products, using fixed gage. Wipes grease and oil from machinery with rags and solvent. May be known according to specific task performed as CONVEYOR MAN; CRUSHERMAN; LOADING CHECKER; MARKER; RACKER; SCRAP BREAKER.

6) Pipefitters

PIPEFITTER. plumber, pipe fitting. Lays out, fabricates, assembles, installs, and maintains piping and piping systems, fixtures, and equipment for steam, hot water, heating, cooling, lubricating, and industrial processing systems, on basis of knowledge of system operation and study of building plans or working drawings: Selects type and size of pipe and related materials according to job specifications. Inspects worksites to determine presence of obstructions and to ascertain that holes will not cause structural weakness. Plans sequence of installation to avoid obstructions and activities of other construction workers. Cuts pipe, using hacksaw, pipe cutters, hammer and chisel, and cutting torch. Threads pipe, using threading machine. Bends pipe by hand or with pipe-bending machine. Assembles and installs variety of metal and nonmetal pipe and pipe fittings, including those made of brass, copper, lead, glass, and plastic. Joins piping by means of threaded, calked, wiped, soldered, brazed, fused, or cemented joints. Secures pipes to structure with clamps, brackets, and hangers, using handtools. Installs and maintains refrigeration and air-conditioning systems including compressors, pumps, meters, pneumatic and hydraulic controls, and piping. Tests piping system for leaks by increasing pressure in pipes and observing gages attached to pipes for indication of leaks. May weld holding fixtures to structural steel members. When installing piping systems that must withstand high pressure is designated STEAM FITTER, AMMONIA; PIPE FITTER, GAS PIPE; or type of piping used as PIPE FITTER, PLASTIC PIPE; PIPE FITTER. SOFT OOPPER.

7) Operating Engineers

OPERATING ENGINEER
--- (const.) heavy-equipment operator. Operates several types of power construction equipment, such as compressors, pumps, hoists, derricks, cranes, shovels, tractors, scrapers, or motor graders, to excavate and grade earth, erect structural and reinforcing steel, and pour concrete: Turns valves to control air and water output of compressors and pumps. Adjusts handwheels and presses pedals to drive machines and control attachments, such as blades, buckets, scrapers and swing booms. May clean, oil, and grease equipment. Worker usually serves an apprenticeship during which he is instructed in the care and operation of increasingly complex machines.

8.2.3. Reclamation

The reclamation method to be employed on resources disturbed during construction would be similar to that used on Units 1 and 2 and its associated pipeline. In general, on land owned by the project, topsoil will be stockpiled, replaced and reseeded where the land use indicates the need. A specific landscaping plan is now being developed for Units 1 and 2 and will extend to Units 3 and 4 if the final design indicates an extension is appropriate. The reclamation steps used on the pipeline would be identical to those used for the construction of the Units 1 and 2 pipeline. These steps were described in detail in the environmental impact statement issued by the Department on the Associated Facilities of Units 1 and 2.

8.3. Coal Content

Coal is a chemically complex rock formed by the accumulation and metamorphism of organic debris. It is found in quantity on all continents and in strata of all ages younger than the

Devonian. North America contains huge quantities of coal ranging in age from Pennsylvanian to Tertiary. Large quantities of Mesozoic and Tertiary coal exists in Montana. The nature and usefulness of the coal depends in part upon the environment in which the organic material accumulated and in part upon the processes acting on it since deposition.

Trees and other plants normally decay after death. The complex organic compounds are broken down into CO_2 and H_2O. To form coal, however, the organic material must be preserved. Standing water into which the debris may fall performs this function. In addition, several other conditions must be met (Bateman 1950):

1) Supply of organic material
2) Only small amounts of mineral sedimentation in basin
3) Time for accumulation
4) Eventual burial and metamorphism

The possible variations in meeting these basic conditions are numerous, and create coals having different compositions and properties. Even within a single bed, the coal differs both vertically and horizontally.

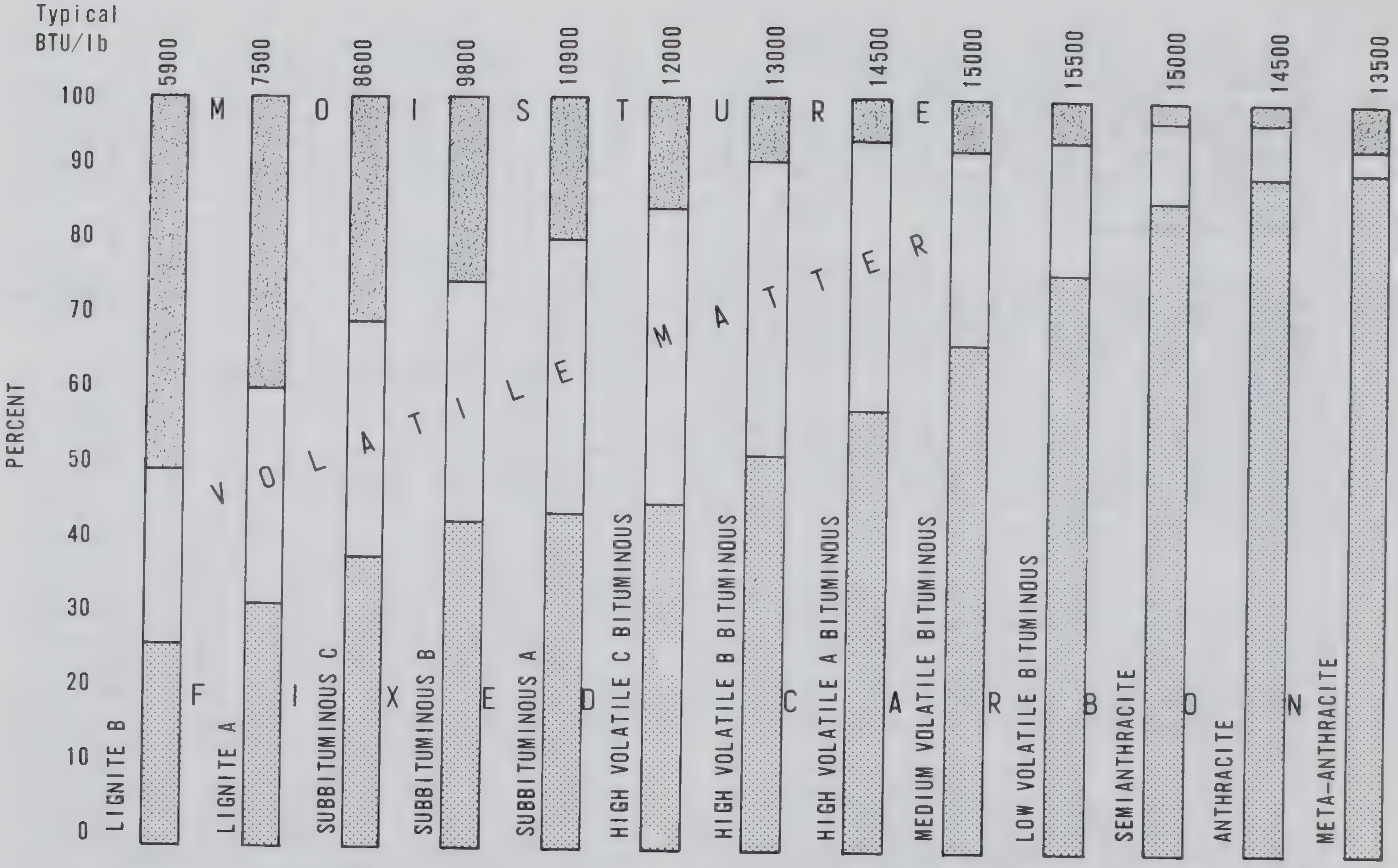
Unlike much of the Pennsylvanian coals of the central and eastern United States which formed at the edge of an oscillating sea, the Fort Union coals of eastern Montana were deposited in fresh water. Streams emerging from the newly-formed Rockies carried clay, silt, and sand into a vast, wet lowland which is now southeastern Montana. Among the channels of the streams, lay swamps and marshes (Jacob 1972 and Royse 1972). Continued subsidence of the basin allowed thick mats of vegetable debris to accumulate but remain wetted. Shifting channels and floodplains would cover the organic layer (peat) with mineral sediment and coal deposition would cease until the environment was re-established. Numerous thick layers of peat were thus formed.

Compression and heating transforms the peat into coal. The degree of compression and heating, especially heating (Teichmuller et al. 1968) determine the rank of the coal. Among other factors, inorganic sedimentation, types of plants making the peat, and the chemistry of the swamp water, overburden, and groundwater determine the sulfur, ash, and trace element content and other properties of the coal.

Coal is classified by rank according to amount of fixed carbon and heat content on an ash-free basis. Figure 8-13 gives typical values for various ranks (ash-free basis).

Coal is further characterized by ash, sulfur, and trace element content. Coal is graded on the basis of its sulfur content and ranges from 0.2-7% in the United States. Coal having less than 1.0% sulfur is considered low sulfur, 1.0-3.0% medium, and more than 3.0% is high. Ash and trace element contents have not been graded (Averitt 1973).

Sulfur is a deleterious substance in coal, It produces sulfur dioxide (SO_2) and sulfur trioxide (SO_3) when the coal is burned. The



Comparison of Fixed Carbon, Volatile Matter, Moisture and Heat Content of Different Ranks of Coal Calculated on an Ash-Free Basis (From Averitt 1973)

FIGURE 8-13

oxides (SO_x) directly damage vegetation, materials, and human health (See Sections 11.1.2., 11.1.5.3, etc.) and react chemically to produce other harmful substances including sulfuric acid (H_2SO_4). Since sulfur removal from the coal and SO_x removal from the flue gases are both difficult, the sulfur content of the coal is an important parameter.

Sulfur occurs partly in the mineral matter, mostly as iron sulfide (FeS_2) in fresh coal and as sulfates ($FeSO_4$ and $CaSO_4$) in weathered coal. Part of the sulfur is chemically bound in the organic matter of the coal (Averitt 1973).

Coal ash consists mostly of inorganic matter swept into the sedimentary basin where the coal was being formed. Ash is undesirable in that it increases transportation and disposal costs and adds to the operational problems of a power plant.

Heat content of coal, expressed in British thermal units (BTU) per pound, is important in plant design and determining the amount of coal which must be mined and handled. This value ranges from less than 7000 BTU for lignite to about 15,000 BTU in higher rank bituminous and anthracite.

Although coal is mostly carbon, hydrogen, and oxygen, most of the natural elements are found, varying in concentration from about 10,000 parts per million (ppm) to the parts per billion (ppb) range. Some elements are inert, some give the coal special properties, and others are important as pollutants. The environmental effects of most elements are not well understood.

8.3.1. Analytical Data

Coal content data are reported from the Rosebud mine (Western Energy at Colstrip). Particular attention is given to mine areas C, D, and E (see Chapter 9, Figure 9-1), from which the coal will be extracted to fire Units 3 and 4 if built; however, the paucity of trace element data from areas C, D, and E necessitates some extrapolation from other parts of the mine. Similarily, the McKay bed is less well known than the Rosebud.

A. Sample Collection and Analyses

Coal analysis data shown in this report are derived from numerous samples gathered over a period of two years or more by several agencies and MPC.

Coal samples from the Rosebud seam were obtained from just-loaded railroad cars at the WECO tipple in June 1972 by Air Quality Bureau personnel. Two samples were sent to EPA in North Carolina who sent all or part of the samples to Battelle Northwest Laboratories in Richland, Washington. Battelle analyzed the samples by neutron activation analysis (NAA) to determine trace element concentrations which are reported in the EIS for Colstrip Units 1 and 2 (HES 1973 Table 8-4). Another sample from this collection was sent to EPA in Cincinnati, Ohio to determine natural radioactivity (HES 1973, Table 8-5). Fluoride concentration was also determined by the Department of Health Laboratory and the University of Montana on these samples (HES 1973, Table 8-4).

Splits of samples of Rosebud coal collected by MPC in late 1972 were analyzed by three chemical laboratories and HES for fluorides. These values were used to obtain the concentration shown in the Units 1 and 2 environmental impact statement (HES 1973, Table 8-4).

Mining areas C, D, and E have been explored by core drilling on a 1,000-foot square grid pattern on those sections in which WECO has exploration rights. This drilling continued into the summer of 1974 and provided numerous samples of the Rosebud seam which have been analyzed by commercial laboratories. These data are shown in Tables 8-1, 8-2, and 8-3 as follows and in Appendix F.

Fifteen cores, sampling the Rosebud and McKay seams, were obtained in June 1974 from mining areas C, D, and E in an agreement between the EPD and MPC. Four of these cores (divided into 30 samples) were delivered to the Branch of Coal Resources, U.S. Geological Survey (USGS) in Denver, Colorado. The USGS sent a split of the samples to the U.S. Bureau of Mines (USBM) in Pittsburgh, Pennsylvania, and performed analyses as shown in Figure 8-14. The results of these analyses are shown in Table 8-4 and Appendix F.

Montana Power Company provided samples of Rosebud coal from Area E and Pit 6 to MSU for trace element analyses. Splits of these samples were provided to the Energy Planning Division. The results obtained from MSU are shown in Table 8-4 and Appendix F. Eight of these samples were analyzed for fluorine by the University of Montana as discussed later in this section.

The uranium, thorium, and radium-226 analyses ("New Data") shown in Table 8-5 were performed by EPA on samples provided by MPC to the Occupational Health Bureau, except for two samples collected by personnel from that bureau.

B. Results

1. Rank

Assuming the mean values presented in Tables 8-1, 8-2, and 8-3 truly represent the value for Rosebud coal in each mining area, a weighted average can be obtained for all coal that is proposed to be mined from the three areas based on their acreage: area C, 7680 acres; area D, 2689 acres; and area E, 723 acres. These weighted averages are (as received basis):

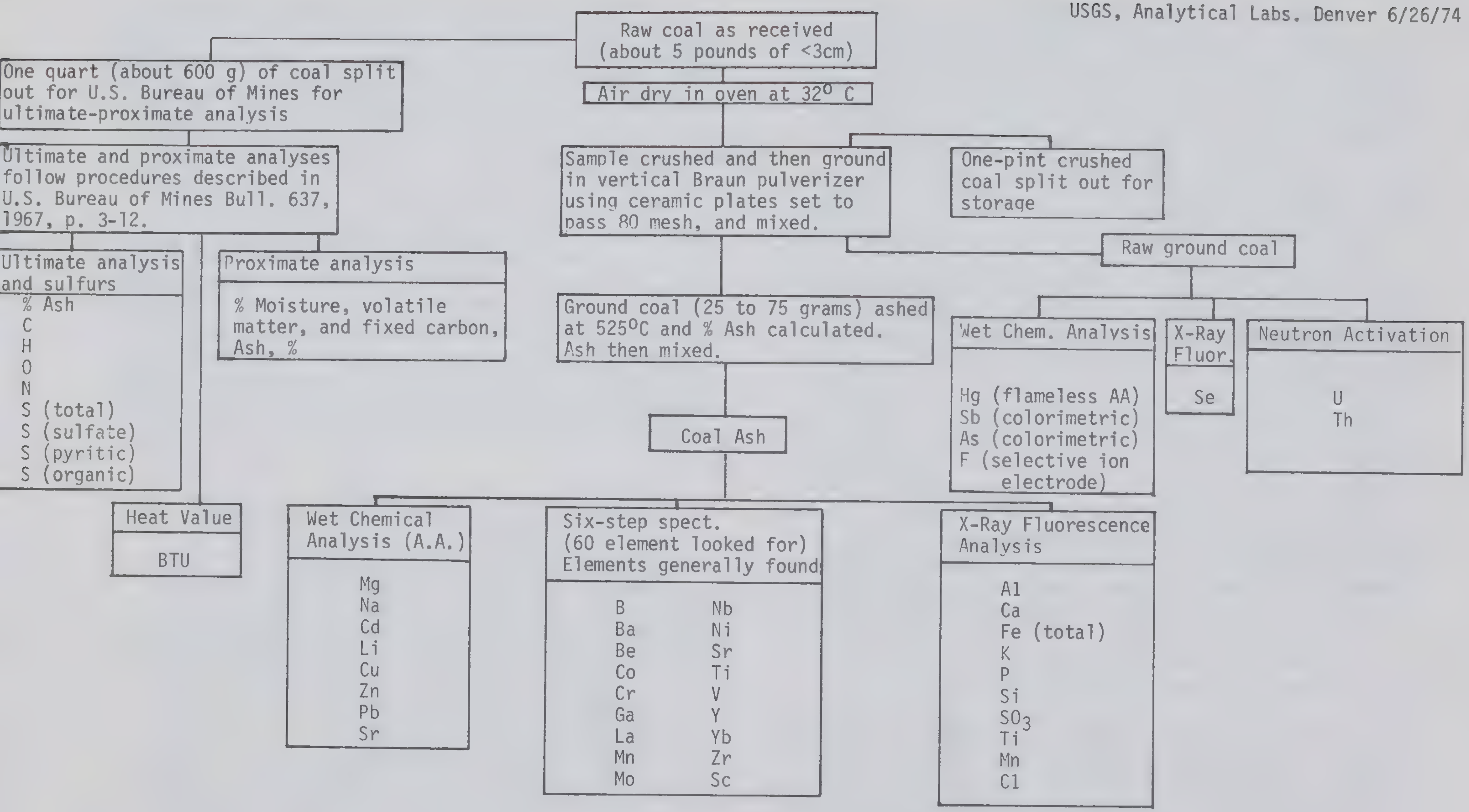
moisture	25.6%
ash	9.57%
volatile matter....	29.7%
fixed carbon	35.1%
heat content	8438 BTU/lb

The same values shown above but calculated on an ash-free basis (for ranking purposes) are:

moisture	28.3%
volatile matter ...	32.8%
fixed carbon	38.8%
heat content	9331 BTU/lb

The McKay coal shows little difference in these values; therefore, both seams are subbituminous in rank (See Figure 8-13).

USGS, Analytical Labs. Denver 6/26/74


Raw coal as received (about 5 pounds of <3cm)
One quart (about 600 g) of coal split out for U.S. Bureau of Mines for ultimate-proximate analysis
Air dry in oven at 32° C
Ultimate and proximate analyses follow procedures described in U.S. Bureau of Mines Bull. 637, 1967, p. 3-12.
Sample crushed and then ground in vertical Braun pulverizer using ceramic plates set to pass 80 mesh, and mixed.
One-pint crushed coal split out for storage
Raw ground coal
Ultimate analysis and sulfurs
% Ash
C
H
O
N
S (total)
S (sulfate)
S (pyritic)
S (organic)
Proximate analysis
% Moisture, volatile matter, and fixed carbon, Ash, %
Ground coal (25 to 75 grams) ashed at 525°C and % Ash calculated. Ash then mixed.
Wet Chem. Analysis
Hg (flameless AA)
Sb (colorimetric)
As (colorimetric)
F (selective ion electrode)
X-Ray Fluor.
Se
Neutron Activation
U
Th
Coal Ash
Heat Value
BTU
Wet Chemical Analysis (A.A.)
Mg
Na
Cd
Li
Cu
Zn
Pb
Sr
Six-step spect. (60 element looked for) Elements generally found
B
Ba
Be
Co
Cr
Ga
La
Mn
Mo
Nb
Ni
Sr
Ti
V
Y
Yb
Zr
Sc
X-Ray Fluorescence Analysis
Al
Ca
Fe (total)
K
P
Si
SO3
Ti
Mn
Cl

FLOW DIAGRAM FOR COAL SAMPLES RECEIVED BY USGS

FIGURE 8-14

2. Sulfur Content

The 165 sulfur-content values for Rosebud coal provided by MPC (Tables 8-1, 8-2 and 8-3) are accepted over the four values obtained by the USBM (Appendix F) on the cores provided by EPD. The small number of samples (four Rosebud and four McKay samples) and the unusually high concentration reported by the USBM make these values questionable. Sulfur analyses of these samples have not been performed to check the validity of the USBM values.

The average sulfur content (weighted on the basis of acreage of the three mining areas) of the Rosebud seam in mining areas C, D, and E is 0.84%. Heat content on a weighted average basis is 8438 BTU/1b, resulting 0.995 lbs sulfur per million BTU.

3. Fluorine

Fluorine occurs in most rock types with an estimated crustal concentration of 770 ppm (Fairbridge 1972). Extremely reactive, it forms fluoride compounds. Its concentration in Colstrip coal (mostly the Rosebud seam) has been reported over a range from less than one ppm to 160 ppm (HES 1973). The value accepted by The Air Quality Bureau of 30 to 40 ppm remains the best estimate (HES 1973). Values reported by the USGS and MSU (Table 8-4) appear high and low respectively. Analyses of eight of the 33 MSU samples by the University of Montana Environmental Studies Laboratory support the accepted value of 30 to 40 ppm. As of this writing, additional analyses have not been run on the USGS samples.

4. Radioactive Trace Elements

Samples of Rosebud and McKay coal were analyzed for gross uranium, gross thorium, and radium-226 content by EPA.

Two naturally occurring families of radioactive elements, the uranium series and the thorium series, account for most of the radioactivity in the coal.

Uranium consists of three isotopes having mass numbers 234, 235, and 238. Uranium-238, (half-life of 4.5 x 109 yrs) has an isotopic abundance of 99.28% and is in equilibrium with uranium-234, (half-life of 2.5 x 105 yrs) whose abundance is 0.0058%. Uranium-235 (half-life of 7 x 10^8 yrs) constitutes 0.71% of the total natural uranium.

Thorium is widely found in nature and is approximately three times as abundant as uranium. Thorium-232, (half-life of 1.4 x 10^{10}yrs) the parent of the thorium series, constitutes nearly all of the thorium.

Unlike most other elements occurring in the coal, radium-226 (half-life of 1.6 x 10^3 yrs) is present only because it is constantly formed by the breakdown of thorium-230. Since the age of the coal is about 60 x 10^6 years, it can be assumed than an equilibrium state between Th-230 and Ra-226 has been reached, barring migration of the elements by groundwater. Essentially all of the radium originally present in the peat has disintegrated. Table 8-5 summarizes the analyses performed on the coal by EPA.

TABLE 8-1

COAL ANALYSIS FOR AREA C (AS RECEIVED BASIS) ROSEBUD SEAM

	%MOISTURE	%ASH	%VOLATILE MATTER	%FIXED CARBON	BTU/LB	%SULFUR
Number Of Values	93	93	93	93	93	93
Minimum Value	20.61	4.14	27.02	29.95	7365	.40
Maximum Value	30.75	18.36	35.26	38.42	9028	7.40
Mean Value	25.65	10.16	29.70	34.47	8383.24	.89
Median	25.40	9.96	29.63	34.42	8423	.80
Standard Deviation	1.488	1.764	1.154	1.361	244.001	.727

TABLE 8-2

COAL ANALYSIS FOR AREA D (AS RECEIVED BASIS) ROSEBUD SEAM

	%MOISTURE	%ASH	%VOLATILE MATTER	%FIXED CARBON	BTU/LB	%SULFUR
Number Of Values	41	41	41	41	41	41
Minimum Value	23.50	7.10	28.30	33.82	8247	.30
Maximum Value	28.63	10.15	31.48	38.86	8810	1.04
Mean Value	25.90	8.31	29.89	35.89	8564.29	.73
Median	25.90	8.19	29.98	35.71	8579	.74
Standard Deviation	1.066	.749	.918	1.090	127.453	.148

TABLE 8-3

COAL ANALYSIS FOR AREA E (AS RECEIVED BASIS) ROSEBUD SEAM

	%MOISTURE	%ASH	%VOLATILE MATTER	%FIXED CARBON	BTU/LB	%SULFUR
Number Of Values	31	31	31	31	31	31
Minimum Value	19.70	6.90	26.70	36.90	8245	.45
Maximum Value	26.50	10.10	31.60	41.30	9182	1.37
Mean Value	24.64	8.19	28.60	38.48	8554.58	.78
Median	24.90	8.10	28.40	38.40	8528	.73
Standard Deviation	1.532	.819	1.049	.974	206.004	.217

TABLE 8-4

TRACE ELEMENT COMPOSITION OF COLSTRIP COAL CONCENTRATIONS IN PARTS PER MILLION (ppm) DRY WEIGHT BASIS

ELEMENT		USGS	MSU	HES (1973)
As	max	45	16	
	min	1	0.6	
	mean	4	5.2	
B	max	100		
	min	30		
	mean	63		
Ba	max	1500		
	min	10		
	mean	325		
Be	max	2.0	1.8	
	min	n.d.	0.1	
	mean	0.3	.47	
Br	min			33
	max			9
	mean			
Cd	max	0.2	1.1	
	min	<0.1	.03	
	mean	<0.12	.25	
Cl		<100		

TABLE 8-4 (cont.)

ELEMENT		USGS	MSU	HES (1973)
Co	max	3		0.48
	min	n.d.		0.40
	mean	<0.5		
Cr	max	10	29	3.0
	min	0.7	<.37	2.8
	mean	3	3.8	
Cu	max	16	15	<100
	min	2.4	4.2	<80
	mean	6.9	8.4	
Eu	max			.085
	min			.075
	mean			
F	max	160	19	30 to 40
	min	<20	5	
	mean	65	11	
Ga	max	7		
	min	1.5		
	mean	3		
Ge	max		3.4	
	min		0.2	
	mean		1.2	
Hf	max			.81
	min			.77
	mean			

TABLE 8-4 (cont.)

ELEMENT		USGS	MSU	HES (1973)
Hg	max	.64	.58	
	min	.01	.07	
	mean	.12	0.2	
La	max	15		4.0
	min	n.d.		3.8
	mean	2.9		
Li	max	21		
	min	1.7		
	mean	10		
Mn	max	190	370	100
	min	13	24	91
	max	58	100	
Mo	max	3		
	min	n.d.		
	mean	<1.2		
Nb	max	2		
	min	n.d.		
	mean	<.8		
Ni	max	5	150	
	min	<.5	1.5	
	mean	<1.4	35	
Pb	max	10	30	
	min	2.4	1.4	
	mean	4.6	5.4	

TABLE 8-4 (cont.)

ELEMENT		USGS	MSU	HES (1973)
Sb	max	2.5	1.8	
	min	.3	<.06	
	mean	1.25	.45	
Sc	max	3		1.0
	min	n.d.		1.0
	mean	.7		
Se	max	2.1	5.1	
	min	<0.1	<.06	
	mean	0.6	1.6	
Sm	max			0.55
	min			0.50
	mean			
Sr	max	500		
	min	30		
	mean	223		
Ta	max			.26
	min			.24
	mean			
Tb	max			.065
	min			.056
	mean			
Ti	max	700		430
	min	41		330
	mean	343		

TABLE 8-4 (cont.)

ELEMENT		USGS	MSU	HES (1973)
V	max	15		7.4
	min	.7		3.6
	mean	5.7		
Y	max	7		
	min	n.d.		
	mean	2.5		
Yb	max	.7		
	min	n.d.		
	mean	.14		
Zn	max	190	100	
	min	15	5.2	
	mean	55	22	
Zr	max	30		
	min	3		
	mean	16		

NOTE: USGS-"Chemical analyses of coal from four core holes in Rosebud County, Montana" (in Appendix) 30 samples of Rosebud and McKay coal from areas C, D, and E.

HES (1973)-Two samples of Rosebud coal sampled from the Western Energy tipple in June 1972. Analyses were performed by Battelle Northwest Laboratories for the Environmental Protection Agency and reported in HES 1973 (except fluorine values which are best estimates of over 60 analyses).

MSU-Montana State University analysis data for 33 samples of Rosebud coal from pit 6 and area E.

n.d. - not detected - < - less than given value

Westinghouse (1973) reported an average value for Hg of 0.15 ppm. Other values given in Westinghouse (1973) are those of HES (1973) except As,B,Be,Cd,Cl,Pb, and Se (origin not known).

TABLE 8-5

RADIOACTIVE TRACE ELEMENTS
ROSEBUD SEAM (NEW DATA)

	Uranium (μg/g)	Thorium (μg/g)	Radium-226 (pC:/g)
No of values	26	26	26
Maximum	2.0	4.3	0.7
Minimum	0.2	1.8	0.2
Mean	1.1	2.6	0.33

McKAY SEAM (NEW DATA)

	Uranium (μg/g)	Thorium (μg/g)	Radium-226 (pC:/g)
No. of values	8	8	8
Maximum	1.0	3.0	0.4
Minimum	0.2	1.4	0.1
Mean	0.75	2.3	0.25

ROSEBUD SEAM (AS REPORTED IN HES 1973)

	Uranium (μg/g)	Thorium (μg/g)	Radium-226 (pC:/g)
No. of values	1	3	1
Value	0.7	1.3	2.8*
		1.5	
		3	

*Since this value was published, the Environmental Protection Agency has stated that the Radium 226 reported for whole coal was a value for the coal ash instead; thus the concentration in the coal is about one tenth that reported, or about .3 pC:/g

5. Other Trace Elements

Table 8-4 represents the best knowledge of trace element concentrations in the Colstrip coal. Although only one set of values exists for many of the elements shown, those elements for which data exist from two or more laboratories generally show good agreement except nickel values. None of the elements appear in abnormally high concentrations.

6. Heterogeneity of Coal

Unlike liquid or gaseous fuels which are homogeneous substances, coal consists of different phases distributed in complex patterns within the seam. This heterogeneity exists at all scales from microscopic to the largest dimensions possible within the seam.

An investigation with a microscope upon a thin section (a slice of coal ground to a thickness of 3-5u) reveals inorganic mineral phases (sulfides, silicates, and others) and several organic phases (the dominant coal material). These phases have different compositions and properties and their relative proportions determine the characteristics of the coal. The iron sulfide phase (pyrite or marcasite), for instance, contributes a large portion of the sulfur. Pyrite contains 53% sulfur, whereas some organic phases are essentially sulfur-free. On a larger scale, pieces and agglomerated masses of pyrite are easily observed as are the bands of different organic phases. The coal may also vary greatly within a distance of a few feet and show major differences in composition from the top to the bottom of the seam. Fracture zones, faults, and other special areas may be the sites of greater pyrite concentration or other variation. The heterogeneity of the swamp that produced the organic matter influences the variability of the existing coal.

Knowledge of the Colstrip coal deposit, except where mined, is derived from core drilling. As noted previously, portions of areas C, D, and E have been cored on a 1,000-foot square grid pattern. The cores are relatively small samples. Numerous small samples can provide reliable mean values for large areas but cannot provide information on local variability. Units 3 and 4 would burn about 903 tons of coal per hour when operating at capacity and using area C coal. The area within four core holes (a 1,000-ft. square) would provide enough coal to operate both units for about 40 days. Large samples (on the order of thousands of pounds) could provide more reliable mean values for a local area and could be used to better understand local patterns of variability, but such samples can be taken only from open mines. Many more cores spaced much more closely could provide the same information but costs would be prohibitive. Therefore, although mean values for entire areas are known reasonably well, the heterogeneity of the coal at the scale which influences hourly, daily, and monthly variations in mean sulfur emissions and other variables is unknown.

8.4. Design Criteria and Functions of Major Plant Components

8.4.1. Boiler

BOILER

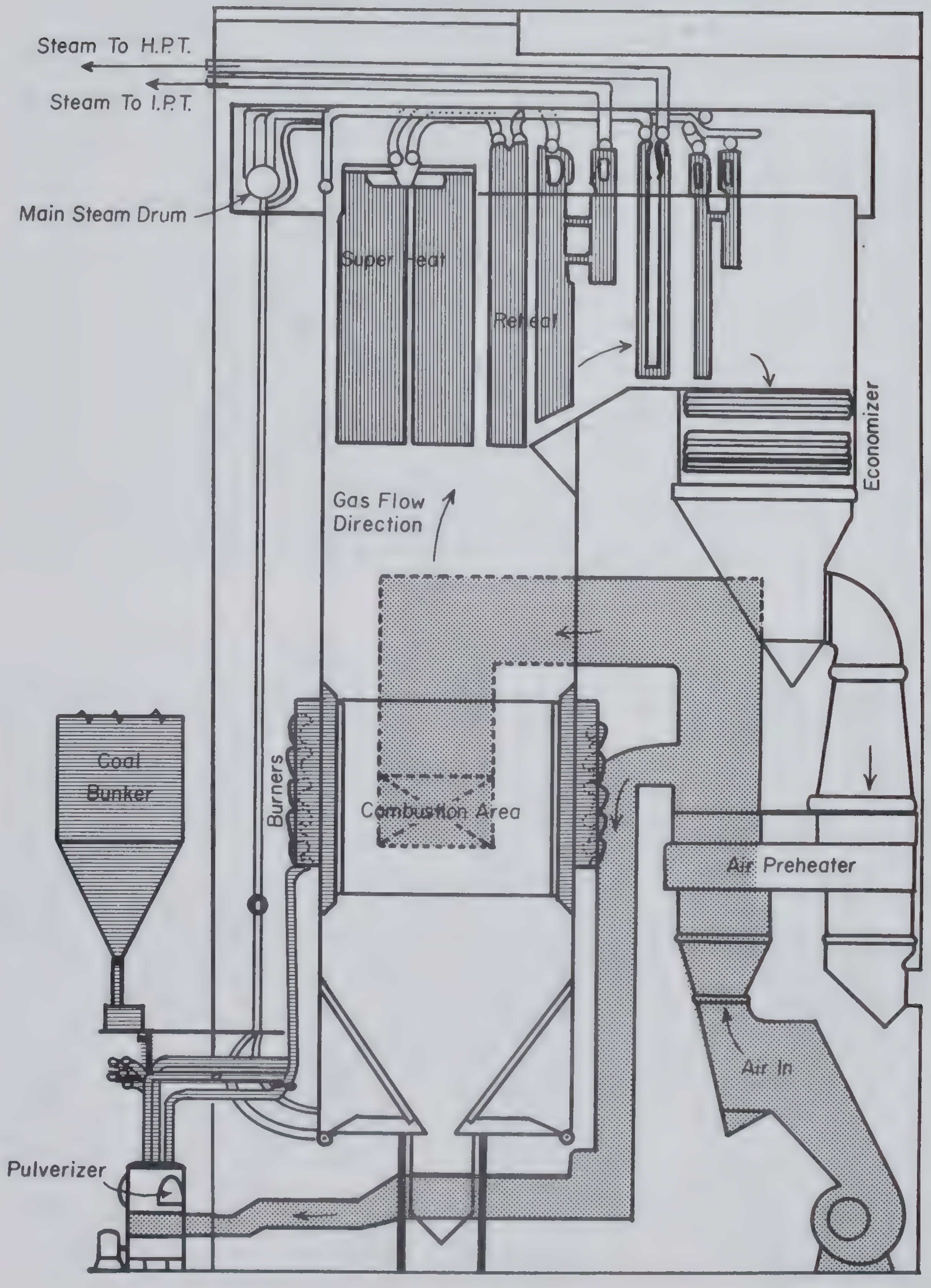


FIGURE 8-15

A boiler is a closed vessel in which water, under pressure, is transformed into steam by the application of heat. Since the primary purpose of the boiler is to generate steam, the term steam generation is sometimes employed. In the boiler, the chemical energy of the fuel is converted into heat and it is the function of the boiler to transfer this heat to the water in the most efficient manner. A boiler should be designed to absorb the maximum amount of heat released in the process of combustion. The heat is transmitted to the boiler by radiation, conduction and convection, the percentage of each depending upon boiler design.

A boiler in service producing steam constitutes a continuous process. Fuel, air and water are supplied while steam and the waste products of ash and flue gases are discharged. A typical water-tube boiler is one in which the products of combustion pass around tubes containing water. The tubes are interconnected to common water channels and to steam outlets. Baffles are installed in the tube banks to direct the gases across the heating surface and to secure maximum heat absorption.

Units 1 and 2 at Colstrip will each use a controlled circulation, radiant reheat, balanced draft steam generator, manufactured by Combustion Engineering Inc. Each will deliver approximately 2,500,000 pounds of steam per hour at 1000°F and 2400 psi, sufficient to drive the turbine at maximum output. The boilers are specifically designed to operate with coal from the Rosebud seam. The boilers will utilize modified tangential type burners which have proven to be effective in reducing the production of NO_2 compounds. The manufacturer guarantees that each unit will produce no more than 0.7 pounds of NO_2 per million BTU. If approved, the boilers for Units 3 and 4 would be similar in design to Units 1 and 2, with the major difference being the much larger size and capacity. Figure 8-15 depicts a boiler similar to the ones proposed for Colstrip.

8.4.2. Steam Turbine Generator

An elementary turbine consists of a shaft on which is mounted one or more disks. Blades are located on the circumference of the disks to receive the steam and convert it into useful work. The rims of the disks have dovetail channels for receiving the blades, and the ends of the blades are made to fit the dovetail channels. The turbine requires bearings for support, a suitable housing or casing to enclose the moving wheel, a system of lubrication and a governor to maintain control over speed. Turbines may be classified as to (1) steam supply (low, medium, high or mixed pressure units), (2) exhaust arrangement (extraction, condensing, noncondensing, or high back pressure), (3) exhaust arrangement (extraction, condensing, noncondensing, or high back pressure), (4) driven equipment (mechanical or electrical generators), and (5) connection to drive unit (direct or geared). High pressure, high temperature turbines are used primarily in large industrial and utility stations. Pressure for these turbines ranges from 400 to 3500 psi. with steam temperatures to 1050 F. Most of the large units operate with reheat. Here the steam

from the high pressure turbine is taken back to a reheater in the boiler where the steam is reheated to its initial temperature.

The turbine generators for Colstrip Units 1 and 2 are General Electric Company, tandem-compound, reheat, double flow, condensing machines. They have a guaranteed nameplate rating of 332,922 KW when supplied with 2400 psi. pressure and 1000°F inlet steam, one inch of mercury exhaust pressure, zero percent makeup and six stages of feedwater heating. The maximum throttle flow is expected to be 2,464,261 pounds per hour, and this should develop 358,371 KW at 3.5 inches of mercury exhaust pressure. The generator is to be directly connected with liquid cooled stator and fan cooled rotor and is designed with a rating of 377,000 KVA at 22,000 volts. If approved, the 700 megawatt Units 3 and 4 are expected to be similar to these units only larger. Figure 8-16 represents a turbine-generator schematic./6

8.4.3. Cooling System

Selection of the cooling system is probably the most important and comprehensive of all the plant design alternatives to be considered. The best alternative system for the dissipation of condenser thermal energy is one which will minimize thermal discharge effects to the environment while optimizing overall power facility economics.

The condensers for Units 3 and 4 would be similar to the condensers for Units 1 and 2 at Colstrip. These condensers are of the single-shell, double-pass surface type with the divided water boxes and are manufactured by DeLaval Turbine, Inc. At the turbine load of 358,371 KW, they are designed to produce an exhaust pressure of 3.5 inches of mercury when operating with 83°F circulating water. Each condenser has an effective surface of 144,000 square feet and is designed for a flow of 103,200 gallons per minute (gpm) of cooling water. For Units 3 and 4 the condenser must be designed for a circulating water flow rate of about 220,000 gpm.

Waste heat will be removed from the turbine steam cycle by a closed loop cooling system using an induced draft evaporative cooling tower. Cooling water is pumped from the cooling tower basin to the condenser and back to the cooling tower. In the cooling tower, large quantities of air are drawn through the sprays of water, and the water is cooled by both sensible heat through contact and by evaporation of the water. The cooling towers selected to meet the foregoing design criteria for Units 3 and 4 each would have overall dimensions of about 65.5 feet by 541.3 feet. These towers would each consist of 15 cells and would extend about 63 feet above the cooling tower basin. The diameter of the fan stack would be about 31.2 feet, yielding a fan stack area of 759.6 square feet. The water circulation rate into each tower would be about 227,000 gpm, and 3.1%, or 7020 gpm would be lost by evaporation. Drift eliminators have been included in the design to reduce entrainment loss, and experience with similar towers indicates that only about 0.005%, or 11 gpm, of the tower flow normally will be discharged as drift. However, the manufacturer only guarantees a drift rate of less

TURBINE GENERATOR CONDENSER PIPING

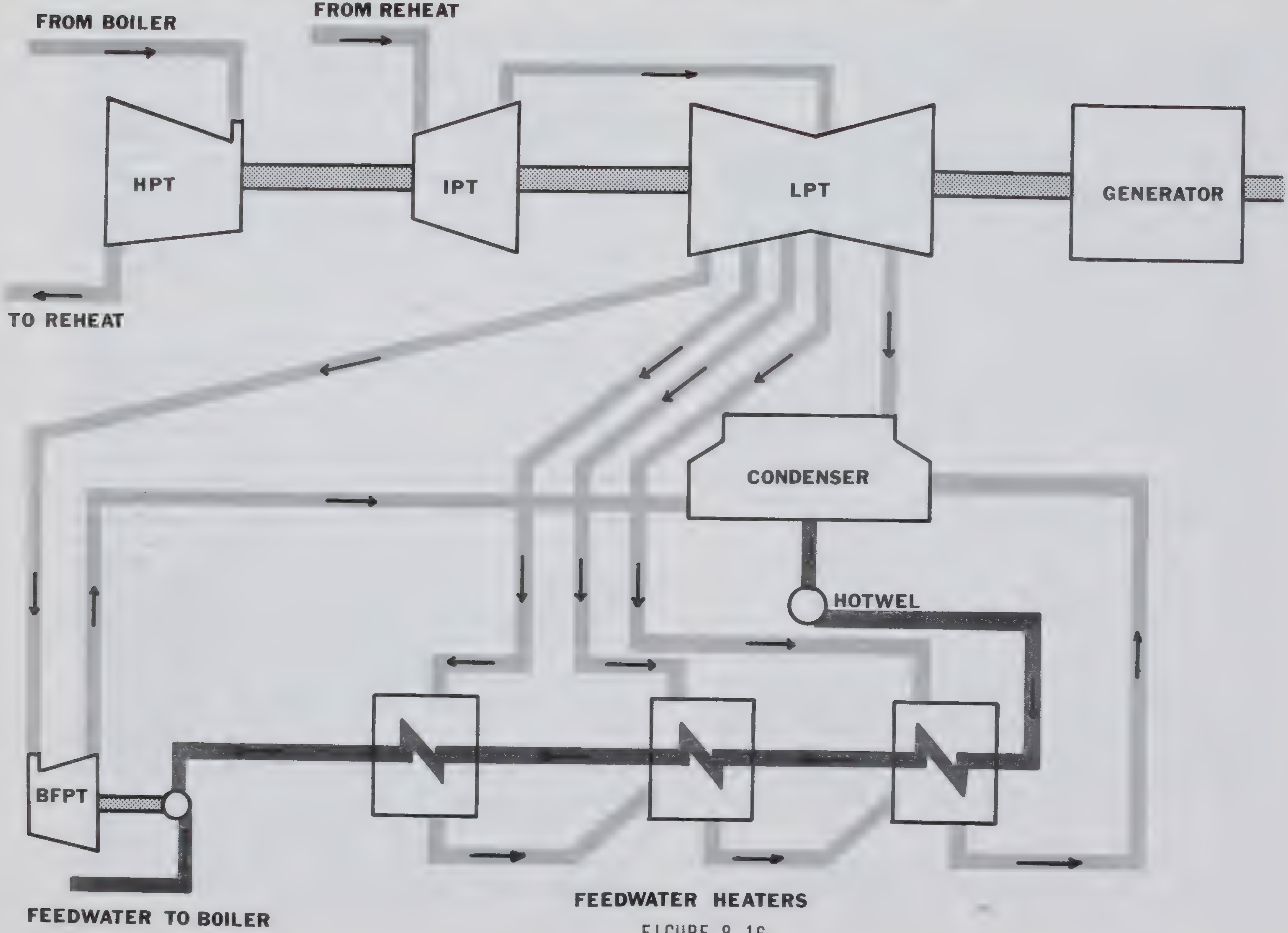


FIGURE 8-16

than 0.02%, or 44 gpm. For an inlet wet bulb temperature of 60°F and a hot water temperature of 113.2°F, this requires an air flow rate through each cell of 1,438,702 cubic feet per minute (cfm) and, for an exit area of 759.6 square feet, an efflux velocity of 1894 feet per minute results. The exit air temperature will depend strongly upon the ambient temperature and relative humidity. Total dissolved solids in the circulating water are expected to be less than 3850 ppm.

8.4.4. Emission Control System

8.4.4.1. Stack Parameters

Stack design can have a significant effect on the dispersion of all pollutants leaving the plant with the combustion gases and, ultimately, on compliance with air quality standards. Units 3 and 4 would each have a 525-foot high reinforced concrete stack. The top inside diameter would be 24 feet, and this is sufficient to provide the desired exit velocity of about 5972 fpm. The temperature of the exit gas is expected to be about 175° F. Each stack would contain an independently supported insulated steel lining with one opening for each of the associated scrubber systems, together with the required EPA test ports. The applicants believe that these stacks will meet all present regulations concerning emission dispersion. The elevation at the stack base is the same as for all units and is around 3220 feet.

As proposed, the emission rate of SO_2 for Units 3 or 4, each with similar control equipment to Units 1 and 2, would be about 7573 lb. per hour.

The emission rate for particulates would be about 367 lb. per hour on each of Units 3 and 4. Since the 99.5% guaranteed particulate removal is based on weight, a smaller percentage of particles less than one micron in size will be removed. The sub-micron (less than one micron in size) particles may be the most dangerous to plant, animal and human life because they are absorbed more readily into life-support systems.

Due to the proposed boiler design, which allows for excess combustion air, the applicants feel that the amount of NO_2 (nitrogen oxide) emitted would be reduced to levels well within state and federal regulations.

The expected emission rate for NO_2 is 5300 lb. per hour. Water vapor should be emitted at the rate of 543,000 lb. per hour per unit. The boiler design and excess combustion air combine to make carbon monoxide emissions insignificant. Of the total design heat input per unit to the boiler (7573 million BTU per hour) approximately 15% (1136 million BTU per hour) is lost as waste heat out the stack. The exit gas density would be 0.05193 lb. per cubic foot and the gas flow volume would be 162 million cubic feet per hour. This all results from a unit boiler consumption of 903,375 lb. per hour of mining area "C" coal.

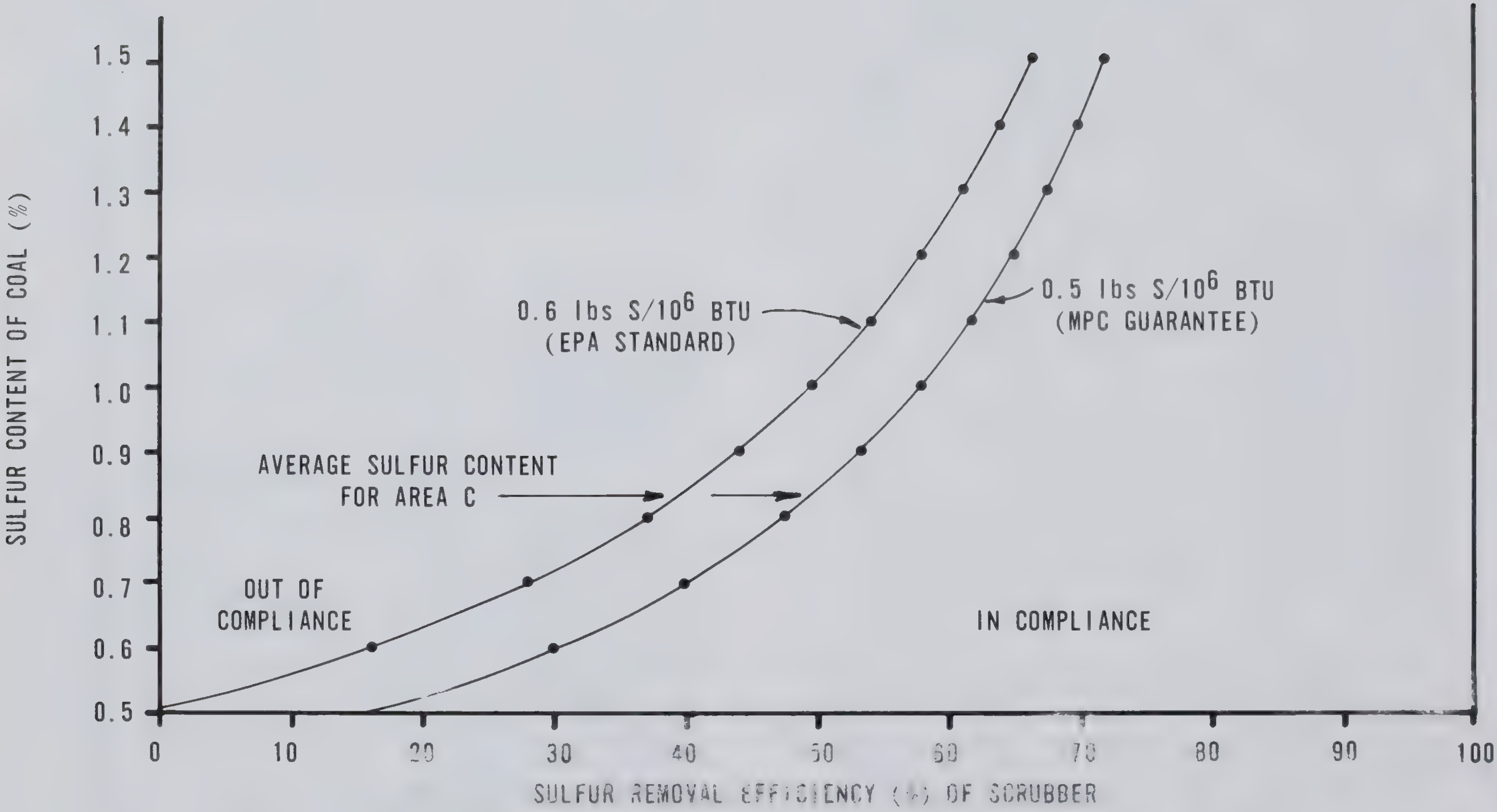
8.4.4.2. Description of Control Efficiencies

From the latest information and data concerning boiler design, scrubber design and coal content analysis for mining areas "C", "D" and "E", Figures 8-17 and 8-18 were derived. Figure 8-17, "Removal Efficiency to Achieve Compliance With Sulfur Emission Standards", shows what the removal efficiency of SO_2 must be in order to meet the standards for various sulfur content in the coal. It also shows what the removal efficiency must be to achieve the one pound of SO_2 per million BTU which the vendor believes will be met. For example, if the sulfur content reaches 1.2%, the control equipment must have a 58% sulfur removal efficiency in order to comply with EPA standards. This figure is based on area "C" coal which contains the lowest BTU content, the highest sulfur content and the highest ash content average of the three areas. A discussion of coal content analysis was presented in Section 8.3. For the particulates, the design control efficiency calls for greater than 99.5% removal. Figure 8-18, "Removal Efficiency to Achieve Compliance With Particulate Emission Standards", shows the removal efficiency necessary to meet the standards for various values of ash content in the coal. This figure is also based on area "C" coal and assumes that 80% and 100% of the ash content of the coal will reach the scrubbers in particulate form. From the final report of the Particulate and Sulfur Dioxide Pilot Plant Test Program for the Colstrip Generating Station conducted by Combustion Equipment Associates, the following removal and sizing information was obtained. The pilot plant successfully removed 99.9% of the particles in the 4 to 5 micron range, 99% of the particles in the 3 to 4 micron range, 98% in the 2 to 3 micron range, 95% in the 1 to 2 micron range, and 90% in the sub-micron or less than micron size range. By design of the boiler, the applicants and the manufacturer believe that the oxides of nitrogen will be well below state and federal standards even though there is no special removal equipment for them. Likewise they believe carbon monoxide should be well below the standards.

8.4.4.3. Trace Element Emission Rates

With the advent of large coal fired power plants such as the proposed Colstrip complex, the possibility of releasing significant quantities of potentially harmful trace elements in coal has increased. In the past and at present, control equipment has not been designed or installed in power plants specifically for the removal of trace elements from the combustion gases. However, of the currently available control systems, the wet venturi scrubber is believed to be one of the most effective control systems for trace element emissions. The reason for this is the ability to remove both particulates and gases. Much concern is being expressed about the possible harmful effects of these emissions and about the quantities of the elements being released.

In Section 8.3. the concentrations in coal

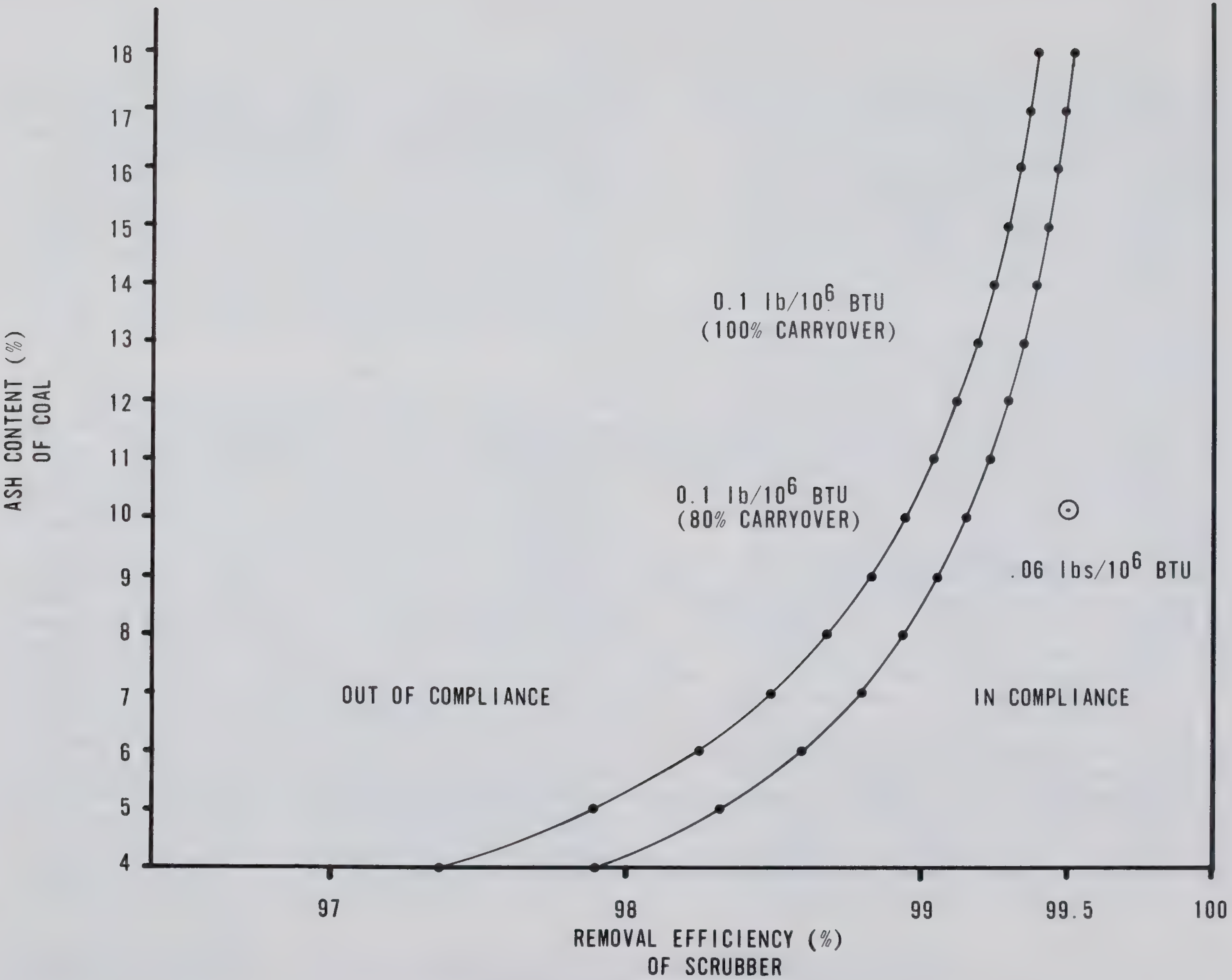


NOTE: 1.0 lb S=2.0 lb SO_2

Curves shown on this graph correspond to 1.2 lbs SO_2 and 1.0 lbs SO_2

REMOVAL EFFICIENCY TO ACHIEVE COMPLIANCE WITH SULFUR EMISSION STANDARDS
AREA C COAL (8383 BTU/lb)

FIGURE 8-17



REMOVAL EFFICIENCY TO ACHIEVE COMPLIANCE WITH PARTICULATE
EMMISSION STANDARDS
AREA C COAL (8383 BTU/lb)
FIGURE 8-18

for various trace elements was presented as the best data available. These values are the basic input data for the model used to develop Table 8-6, "Estimated Trace Element Emission Rates", for the proposed Colstrip Unit 3 or 4. In developing this model, the melting point and the boiling point for each element and its oxide was considered (Handbook of Chemistry and Physics, 51st Edition 1970). The values of melting point and boiling point were used to help classify each element as refractory, intermediate, volatile or special.

These classifications were based on the volatilization-condensation model suggested by Natusch et al. (1974, p. 202) and supported by independent work of Kaakinin et al. (1974 p. 13). The trace elements volatilize in the boiler to different degrees depending on their individual boiling point temperatures. After volatilization the gases are cooled to a temperature of approximately 300° F prior to entering the scrubber. As a result of this cooling, the trace element gases condense on the particulate matter suspended in the gas stream. Because of the greater surface area per unit mass of smaller particles, the condensing trace elements will concentrate on the smaller particle size fraction. Due to the concentration on smaller particles and the decreased removal efficiency of smaller particles, the emission rates of many trace elements are thought to increase with the degree or amount of volatilization. Assuming this to be true, the following classifications have been developed.

1) Refractory - The elements for which the metal and the oxide have melting points greater than 1500°C which is about the temperature in the boiler. These elements were assumed not to concentrate on small (sub-micron) particles because they do not readily volatilize. Assuming 99% particulate removal efficiency, elements of this classification were assigned 1% emission.

2) Volatile - The elements which were thought to volatilize completely in the boiler and have the greatest concentration on the small particles. Because the scrubber particulate removal efficiency decreases as the particle size decreases, the sub-micron particle removal efficiency drops to approximately 90%. If all of the trace elements condensed on the sub-micron particles, then a 10% trace element emission would result. Another method is to assume an overall particulate removal of about 99% with a trace element concentration factor of 10. This again results in a 10% trace element emission which was assumed for the elements in this classification.

3) Intermediate - The elements (except mercury, and the halogens) which were not included in the refractory or the volatile classifications. These elements were assumed to be partially volatilized so that some concentration on small particles was assumed. An intermediate value of 5% emission was as-

TABLE 8-6

ESTIMATED TRACE ELEMENT
EMISSION RATES (FOR UNIT #3 OR #4)

Element	Assumed Concentration ppm	100% Cap Feed Rate lbs/hr	Percent Emitted	100% Cap Emission Rate lbs/hr	100% Cap Emission Rate g/sec
As (arsenic)	5	3.36	10	.336	.0423
B (boron)	65	43.7	5	2.185	.275
Ba (barium)	325	218	5	10.9	1.37
Be (beryllium)	0.5	.336	5	.0168	.0021
Br (bromine)	25	16.8	10	1.68	.212
Cd (cadmium)	0.2	.134	10	.0134	.00169
Cl (chlorine)	100	67.2	10	6.72	.847
Co (cobalt)	0.5	.336	1	.00336	.00042
Cr (chromium)	3	2.02	5	.101	.0127
Cu (copper)	7.5	5.04	5	.252	.0318
Eu (europium)	.08	.054	5	.0027	.00034
F (fluorine)	35	23.5	10	2.35	.296
Ga (gallium)	3	2.02	5	.101	.0127
Ge (germanium)	1.2	.807	10	.0807	.0102
Hf (hafnium)	0.8	.538	1	.00538	.000678

ESTIMATED TRACE ELEMENT
EMISSION RATES (FOR UNIT #3 OR #4)
(continued)

Element	Assumed Concentration ppm	100% Cap Feed Rate lbs/hr	Percent Emitted	100% Cap Emission Rate lbs/hr	100% Cap Emission Rate g/sec
Hg (mercury)	0.2	.134	90	.121	.0152
La (lanthanum)	3.5	2.35	1	.0235	.00296
Li (lithium)	10	6.72	5	.336	.0423
Mn (manganese)	100	67.2	5	3.36	.423
Mo (molybdenum)	1.2	.807	10	.0807	.0102
Nb (niobium)	0.8	.538	1	.00538	.000678
Ni (nickel)	35	23.5	5	1.175	.148
Pd (lead)	5.0	3.36	10	.336	.0423
^{226}Ra (radium)	0.3 pCi/g	92×10^{-6} Ci/hr	5	4.6×10^{-6} Ci/hr	1.28×10^{-9} Ci/hr
Sb (antimony)	1.0	.672	10	.0672	.00847
Sc (scandium)	1.0	.672	1	.00672	.000847
Se (selenium)	1.0	.672	10	.0672	.00847
Sm (sarmarium)	0.5	.336	5	.0168	.00212
Sr (strontium)	225	151	1	1.51	.190
Ta (tantalum)	.25	.168	1	.00168	.000212
Tb (terbium)	.06	.040	5	.002	.000252

ESTIMATED TRACE ELEMENT
EMISSION RATES (FOR UNIT #3 OR #4)
(continued)

Element	Assumed Concentration ppm	100% Cap Feed Rate lbs/hr	Percent Emitted	100% Cap Emission Rate lbs/hr	100% Cap Emission Rate g/sec
Ti (titanium)	400	269	1	2.69	.339
Th (thorium)	2.5	1.68	1	.0168	.00212
U (uranium)	1.0	.672	1	.00672	.000847
V (vanadium)	6	4.03	5	.202	.0255
Y (ytterium)	2.5	1.68	5	.084	.0106
Yb (ytterbium)	.15	.100	10	.01	.00126
Zn (zinc)	50	33.6	10	3.36	.423
Zr (zirconium)	16	10.8	1	.108	.0136

sumed for these elements.

4) Special - These are the elements mercury, fluorine, bromine and chlorine. Actual mercury balances on power plants have been conducted and the results indicate 90% emission for mercury (C.E. Billings et al. 1973 and Billings 1972). Based on Montana Power pilot plant scrubber tests, fluoride control averaged about 90% (Holtz 1974) From these results and the assumption that bromine and chlorine would act similar to fluorine, an emission of 10% was assumed.

In establishing the estimated emission rate for each trace element a percentage emission was applied to the feed rate. This percentage figure was determined by making several assumptions based upon the characteristics of the scrubber and the volatility of the element or its oxide. Refractory elements are assumed to be uniformly distributed through the fly ash and are not concentrated in any size fraction. Their removal efficiency, therefore, should be that of the fly ash (99.5%). The use of one percent in calculating emissions allows for a small amount of concentration in the uncollected fly ash and represents the maximum likely emission.

The use of 10% emission for the volatile elements was arrived at by two rationales. The first assumes that all of the trace element is volatilized in the boiler and condensed upon sub-micron particles. Since the removal efficiency of the sub-micron particles in the scrubber is about 90%, the upper limit of trace element emission is 10%, given the above assumption; however, 10% is high because the trace elements also condense upon the larger particles (greater than one micron). The second rationale assumes complete condensation of the volatile trace elements and a concentration factor of 10 in the particulate matter which escapes the scrubbers. Since the escaping particulate is less than one percent of the total particulate generated, 10% of the volatile trace elements is considered the maximum amount that could escape the control devices.

The intermediate elements are assigned an emission factor of five percent based upon the assumption that their behavior in the boiler and the ducts is intermediate between the refractory elements and the volatile ones.

The emission factors are believed to be in error on the high side and the intention here is to demonstrate the highest emissions likely to occur. The percentage figures applied as emission factors are not portrayed as being exact.

8.4.5. Sludge Disposal

One of the major problems inherent in flue gas desulfurization systems based on lime or limestone is the necessity to dispose of or utilize large quantities of sludge. At present, lime/limestone scrubbing systems generate a sludge with little commercial value. Lime scrubbing proccess ordinarily produce sludges containing $CaSO_3 \cdot 1/2\ H_2O$, $Ca(OH)_2$, $CaSO_4 \cdot 2H_2O$ and $CaCO_3$; while limestone sludges generally contain $CaSO_3 \cdot 1/2\ H_2O$, $CaSO_4 \cdot 2H_2O$, and $CaCO_3$. For coal-fired installations where efficient particulate removal is not installed upstream of the absorber, such sludges can contain large quantities of fly ash.

The amount of sludge generated by a given plant is a function of the sulfur and ash content of the coal, the coal usage, the on-stream hours per year (load factor), the mole ratio of lime or limestone added to the amount of SO_2 removed, the SO_2 removal efficiency, the ratio of sulfite to sulfate in the sludge, and the percent moisture in the sludge. Table 8-7 lists values of these various sludge parameters for a hypothetical plant representing the national average expected between 1973 and 1980.

The SO_2 removal efficiency will vary from one flue gas desulfurization system to the next as a function of local requirements. Typically, an SO_2 removal efficiency of about 85% is required to meet the standards for plants burning eastern coal. This, however, is not true at Colstrip if Rosebud seam coal is burned. Removal efficiency necessary to meet current standards, was presented in Section 8.4.4.2.

Since unreacted additive is disposed of with the sludge, the stoichiometry of lime or limestone addition (the CaO/SO_2 or $CaCO_3/SO_2$ mole ratios) greatly influences the amount of sludge to be handled. The CaO/SO_2 and $CaCO_3/SO_2$ mole ratios vary from system to system at present, but the general trend is toward lower values as operating experience is gained. Reasonable values for this ratio are 1.0 and 1.2, respectively.

Table 8-7

TYPICAL SLUDGE PRODUCTION PARAMETERS

Sludge Production Parameters	National Average
Coal:	
Sulfur Content	3.0%
Ash Content	12%
Plant:	
Load Factor	73%
Coal Usage	0.88 lb/KWh
Scrubbing Systems:	
SO_2 Remvoal Efficiency	85%
Moisture in Sludge	50%
CaO/SO_2 (inlet) Mole Ratio	1.0
$CaCO_3/SO_2$ (inlet) Mole Ratio	1.2
Sulfite/Sulfate Mole Ratio	9:1

As stated previously, the amount of sludge produced by a plant is directly proportional to the number of hours per year that the plant operates and the coal usage of the plant. The 6400 hr/year and 0.88 lb coal/KWh values used for those calculations are typical of large modern generating stations. Obviously, if the plant is on line a larger fraction of the year or more coal is required per KWh, the amount of sludge produced will increase. The sulfite to sulfate ratio in the sludge affects the weight of the sludge produced as $CaSO_4 \cdot 2H_2O$ is heavier than $CaSO_3 \cdot 1/2\ H_2O$. The ratio assumed in this discussion is 9:1.

Ponding and landfilling currently provides the major mechanism for disposal of lime/limestone sludges from flue gas desulfurization systems. As such, there are three problems associated with this practice. First, the land use for waste disposal is aesthetically objectionable. Second, the sludge could provide varying degrees of surface and groundwater pollution depending upon chemical composition, solubilities, and the location, design, and operation of the disposal site. The potential water pollution problems derived from the chemical composition of the sludge may be classified as:

1) Soluble toxic species (toxic meaning elements which can cause health problems even at low concentrations),
2) Chemical oxygen demand,
3) Excessive total dissolved solids,
4) Excessive levels of specific species, e.g., sulfate and chloride, not generally thought of as a toxic, and
5) Excessive suspended solids (some of which might dissolve later).

Thirdly, for land reclamation, most of the stable wastes will require only a cover material to support vegetation and prevent eventual erosion. However, some wastes are very resistant to dewatering and could reslurry in the pond or landfill. If this is shown to be true, it is likely that chemical fixation will become a necessary practice. Chemical fixation of limestone scrubber sludge is currently being practiced at the Will County, Illinois Station of Commonwealth Edison.

The alternative to disposal of scrubber sludges is development of commercially applicable utilization processes. Numerous programs in this area have been conducted through government sponsorship and by industry. These may be summarized as:

Sludge Utilization Schemes

1) Filler Material
    - A. Structural Fill
    - B. Mine Void Fill
    - C. Filler in Bituminous Concrete
    - D. Waste Disposal/Sanitary Structural Landfill
2) Pozzolanic Products
    - A. Road Base Course
3) Autoclave Products
    - A. Concrete Admixture (Structure and Products)
    - B. Fired Brick
    - C. Lightweight Aggregate
4) Pressure Sintered Products
    - A. Metal Coatings
    - B. Pipes
5) Gypsum Products

A. Plaster
B. Wallboard

6) Soil Amendment

7) Mineral Wool

8) Mineral Recovery

A. Lime
B. Aluminum
C. Iron
D. Pozzolan (glass particles)
E. Titanium
F. Silicon
G. Rare Elements

9) Sulfur Extraction

A. Sulfur
B. Sulfuric Acid

10) Polluted Water Treatment

A. Recovery of polluted streams, ponds, lakes
B. Neutralization of Acid Mine Drainage and Polluted Waters
C. Sewage Plant Treatment

Although many of the above schemes have been proposed as uses for lime/limestone scrubber sludges, none is being currently utilized by the U.S. power industry.

8.4.6. Water Supply and Treatment System

The applicants' proposed water supply system for Units 3 and 4 would be an addition to the water supply system for Units 1 and 2. That system was described in detail in the environmental impact statement for the Colstrip Units 1 and 2 Associated Facilities application. If approved as proposed, the additions for Units 3 and 4 would consist of a 36-inch pipeline from the pump house on the Yellowstone River to the surge pond near the plant site. A third 4000 horsepower motor driven pump would be installed with the two existing ones to provide the necessary pumping capacity for the 36-inch pipe. Two of the pumps would feed the 36-inch pipe and one would feed the 26-inch line. The 36-inch line would also be routed to the surge pond with a bypass system going directly to the plant. Since all four units would use the existing surge pond if the proposed system is approved, the reserve water capacity would be reduced from 50 days for Units 1 and 2 to approximately 17 days for all four units. The surge pond is necessary so that in times of extreme low river flow, the withdrawal from the river can be stopped to protect the ecosystem of the river. The state has the authority to control the use of water when necessary. Therefore, the surge pond must be able to supply water when the pump house on the river is shut down.

Water going into the plant, whether from the surge pond or directly from the river, would pass through clarifiers where the clay and remaining fine particles of sand are removed. The buildup in the clarifier would be blown down to a settling basin which would be periodically dredged. Water would be decanted from the settling basin and returned to the clarifier inlet with chlorine added to the clarifier inlet water to control bacteriological growth. Alum and polyelectrolyte would be added as coagulant aids to help remove the remaining silt.

Up to 90% of the water would flow from the clarifier through the main steam condensors and to the cooling towers. The remaining water would pass through a secondary clarifier for further clay removal and then be pumped through pressure sand filters for further clarification. The filtered water is then routed to a filtered water tank. From the filtered water tank, two 100 gpm pumps would deliver water to the plant domestic water system and to the chemical treatment system.

Boiler feedwater or makeup water to the boiler comes from the filtered water tank to be purified in a demineralizing water system. The water first passes through a cation exchanger train and then a forced draft decarbonator. Decarbonator booster pumps then deliver the water to the anion exchangers and finally to a mixed-bed demineralizer. Upon leaving the demineralizer, the water is highly polished or purified and is delivered to the condensate storage tank or to the condenser hotwell for makup to the feedwater syster. Sulfuric acid, which is used as a regenerant for the cation exchange train, and sodium hydroxide, which is used as a regenerant for the anion exchange train, are fed to a neutralizing tank where they mix to form an essentially neutral solution which can be released to the ash pond.

Even though the boiler water is highly polished and purified, small quantities of corrosion inhibitors must be added to the system. Sodium sulfite and hydrazine are added to remove oxygen; sodium phosphates and ammonia are added to control pH and scaling. As these chemicals are added, solids build up in the boiler water system. Experience has indicated the levels at which these solids must be maintained for proper boiler operation, therefore the boiler will be blown down continuously to maintain that residual. The blowdown will be cooled and piped to the cooling tower circulating water for use in that system. As solids build up in the cooling tower water, that system is also blown down. The applicants propose to use cooling tower blowdown in the scrubbers, but whether this is done or not, it will eventually end up in the ash pond. This results in all chemcials which are added to the various water systems ending up in the ash pond.

8.4.7. Fuel Handling System

Coal for the proposed units would be delivered by truck to an unloading hopper approximately 1500 feet east of Unit 4 (see Figure 8-1). The coal is routed through a crusher which reduces the size to less than 1.5 inches, then the coal is belt-fed to the stockpile. The stockpile is an area about 750 feet by 1350 feet which would hold enough coal for 90 days operation at full load of all four generating units. Two reclaim hoppers would be located under this stockpile, one for Units 1 and 2 and another for Units 3 and 4. A trench would be dug around the stockpile to catch drainage water which would be routed to a place of impoundment where the coal dust would be allowed to settle out before discharging the water. As coal is needed for burning, it could be reclaimed and again belt fed into coal bunkers adjacent to the unit boilers. The bunkers are vented and have filters to prevent coal dust from escaping to the atmosphere. The belt conveyors also would be covered to help prevent coal dust from entering the atmosphere.

From the bunkers, the coal passes through feeders which regulate the amount of flow to the pulverizing mills. The coal is pulverized to a fine dust (70% of the coal must pass through a 200 mesh screen) and transported by air flow to the four corners of the boiler. Each pulverizer supplies coal to four burner assemblies or one burner level.

From the Westinghouse Environmental Analysis (1973, p. 2-93) comes the following description.

> Each burner assembly will be composed of a vertical arrangement of compartmented fuel and air nozzles equipped with tilting tips in an insulated wind box. Above the uppermost auxiliary air nozzles will be two overfire air ports equiped with tilting nozzles; these will control formation of nitrogen oxides. In this system the normal amount of combusion air is distributed to a greater volume of the furnace than in a normal tangentially fired unit. This greater distribution reduces both the minimum flame temperatures and the amount of available nitrogen at any particular location in the flame. As a result, nitrogen oxide products are reduced substantially below those found with a normal tangentially fired unit.

The supplier, Combustion Engineering Company, of the overfire air system, guarantees that less than 0.7 lb. per million BTU of nitrogen oxides, which is the current federal emission standard, will leave the unit. The entire system is designed to ensure that combustion will be complete in all stages and that the flue gas will comprise the products of completely burned coal. Other than flue gas, the principle product of burning coal will be bottom ash, fly ash entrained in hoppers of the economizer and finally fly ash is carried through to the scrubber.

8.5 Material Flow Diagram

8.5.1. Plant Water Analysis

Typical winter water usage for the entire plant, including all four generating units, is illustrated in Figures 8- 19 through 8-26, and similar information for typical summer operation is presented in Figure 8-27 through 8-34 Figures 8-19 and 8-27 show the surge pond water balance. The miscellaneous usage from the surge pond includes dust control, reclamation, etc. Figures 8-20 and 8-28 indicate overall plant water flows in a general sense. Water flows through generating Units 1 and 2, including associated clarifier and water treatment facilities, are shown in Figures 8-21 and 8-29, and similar information for Units 3 and 4 is given in Figures 8-22 and 8-30. From Figures 8-21 and 8-29 it may be observed that water for domestic use in the Colstrip complex would be taken from the water treatment facilities associated with Units 1 and 2.

Detailed water budgets for either Unit 3 and 4 are shown in Figures 8-23 and 8-31, and Figures 8-24 and 8-32 show detailed budgets for either Unit 1 or 2. It is somewhat doubtful that the cooling tower blowdown would be suitable for use in the scrubbers, as indicated in these figures. In this event the cooling tower blowdown would have to be disposed of in some other fashion, and additional water would have to be supplied from the Yellowstone River to the scrubbers. Detailed water balances for the scrubbers are indicated in Figures 8-25 and 8-33 for Units 3 and 4, and in Figures 8-26 and 8-34 for Units 1 and 2.

8.5.2. Plant Air Analysis

A typical air flow analysis for either generating Unit 1 or 2 is illustrated in Figure 8-35 It may be observed that air enters the boiler where it participates in the combustion process. The gaseous products of combustion then flow through the scrubbers to a reheater and are then forced out the stack by a fan. The total gas flow out the stack is 3,977,000 pounds per hour so each scrubber must handle 1,325,667 pounds per hour. For Units 3 and 4 the air flow analysis is shown in Figure 8-36 Here, 8,436,000 pounds per hour of gaseous products are lost from the stack and each scrubber must handle 1,205,143 pounds per hour.

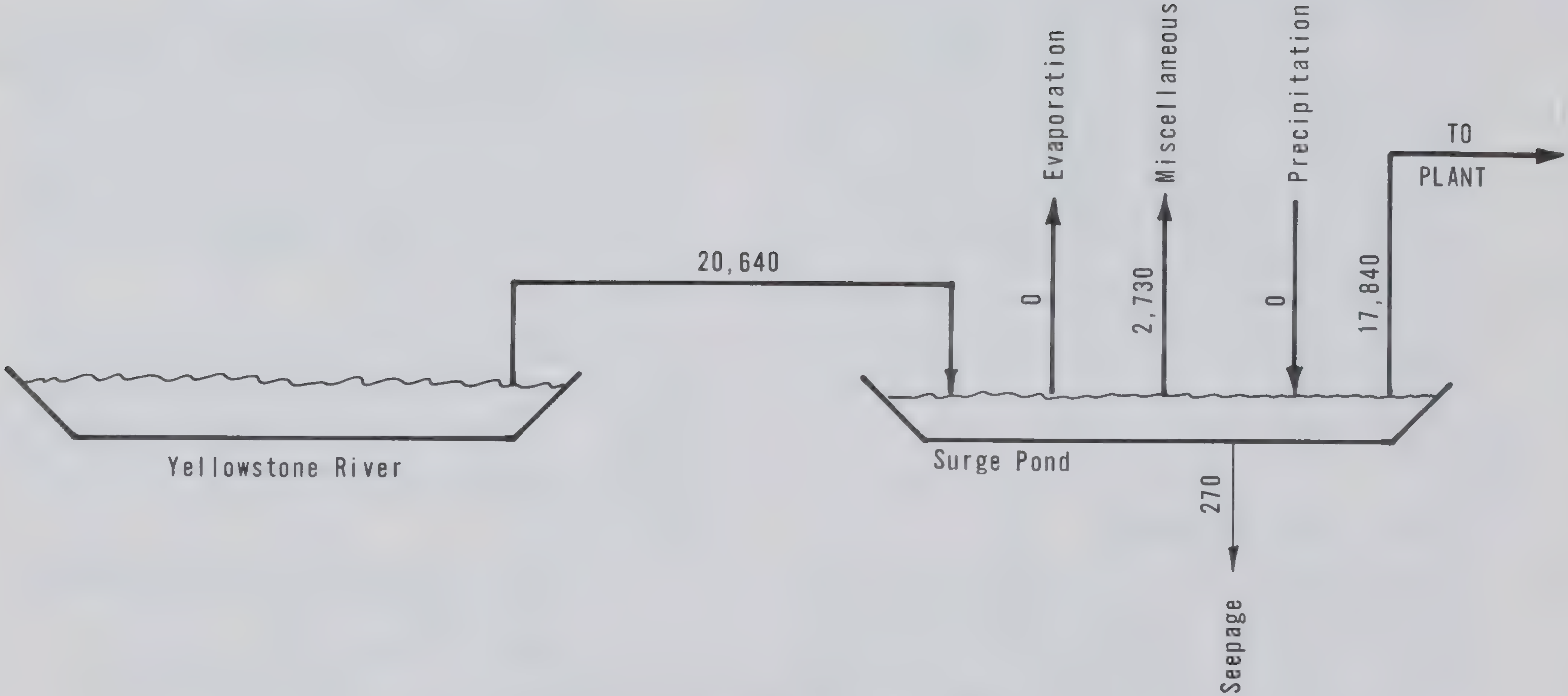
8.5.3. Plant Coal Conversion Analysis

Figure 8-37 is a material flow diagram for the major constituents of the coal which will be burned in proposed Units 3 or 4. The trace elements have not been accounted for in this figure because they were discussed in Section 8.4.4.2. Also, this figure was developed assuming 7573 million BTU per hour heat released in the boiler and burning coal from mining area "C". The coal analyses for this area were presented in Section 8.3.

Assuming 23% excess combustion air, the manufacturer guarantees that only 0.7 lbs. of NO_x per million BTU heat release will be emitted. It is not known exactly how much carbon monoxide will be formed. This will depend both on the amount of excess air and on the boiler design. Other assumptions made in developing this flow diagram were:

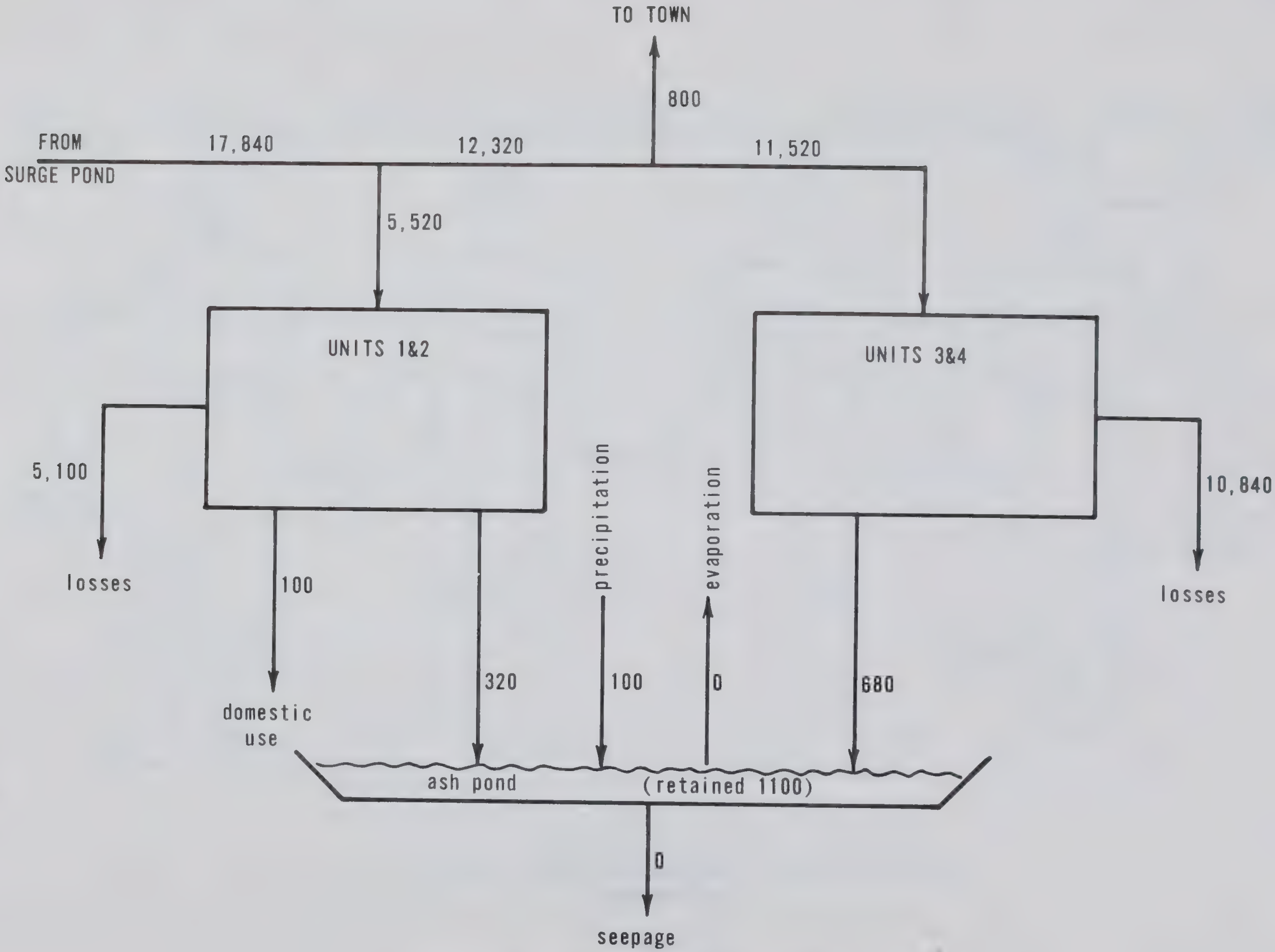
1) 20% ash removal in the boiler and economizer hoppers.
2) 99.5% ash removal in the scrubbers.
3) 40%, 50%, and 60% removal of SO_2 in scrubbers.

The SO_2 removal in the scrubbers depends on the available calcium, potassium, and sodium in the fly ash. If the available alkalinity in the fly ash varies considerably then some method probably would be employed to maintain the desired level. The method chosen would determine

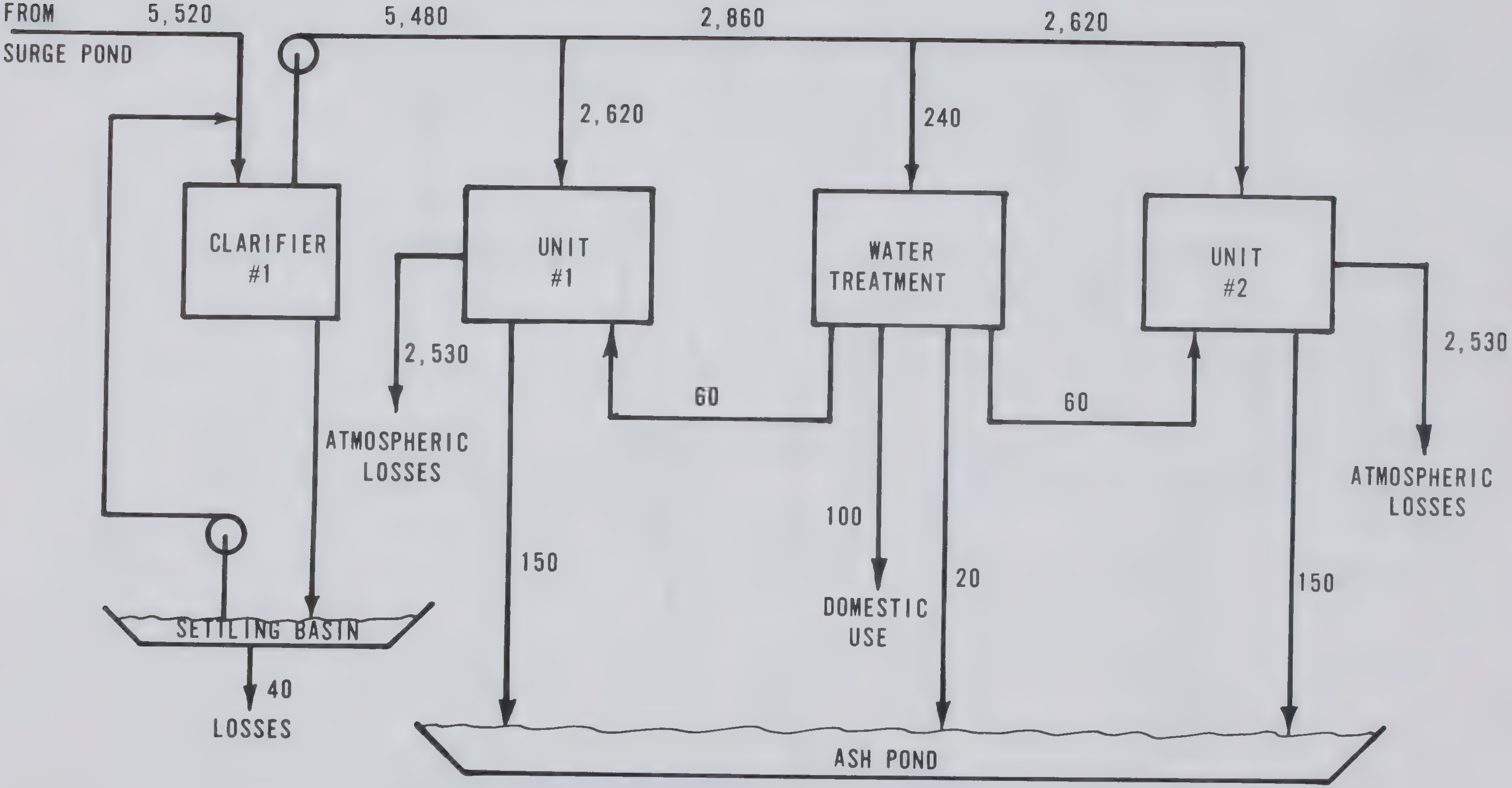


WINTER WATER BUDGET FOR SURGE POND
(ALL VALUES ARE GPM)

FIGURE 8-19

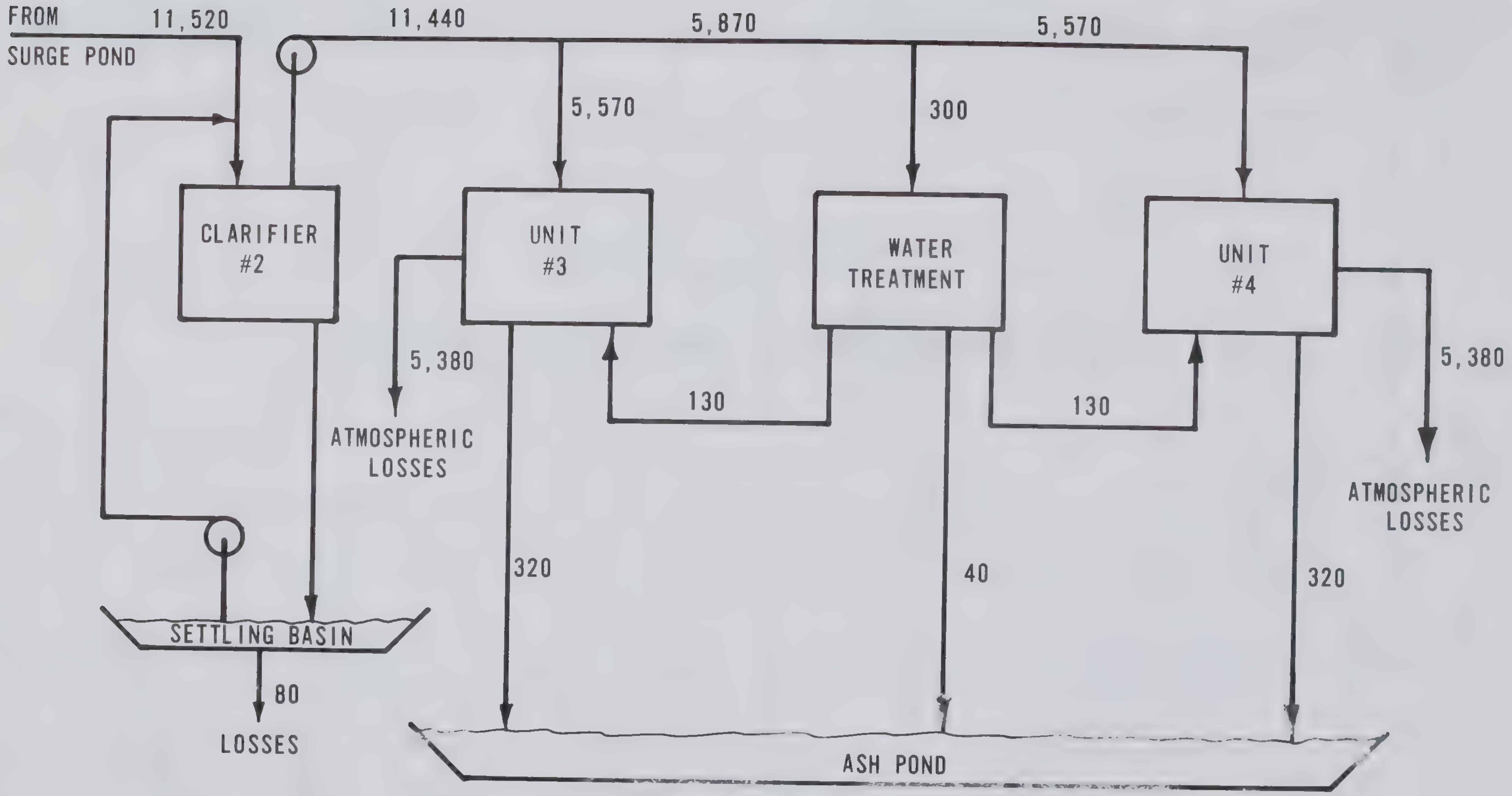


WINTER WATER BUDGET FOR OVERALL COMPLEX
(All Values are GPM)
FIGURE 8-20



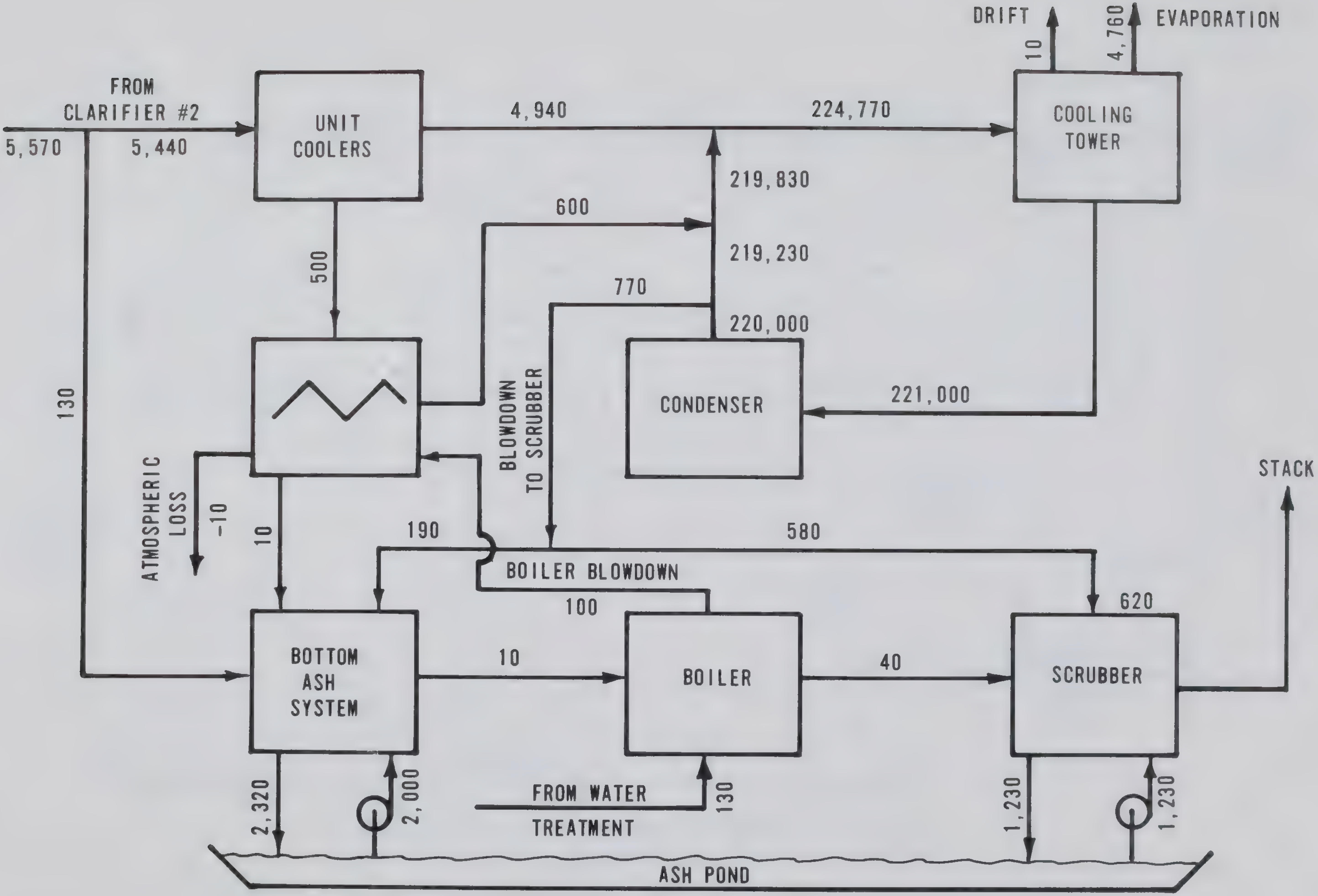
WINTER WATER BUDGET FOR GENERATING UNIT #1 AND #2
(VALUES ARE GPM)

FIGURE 8-21



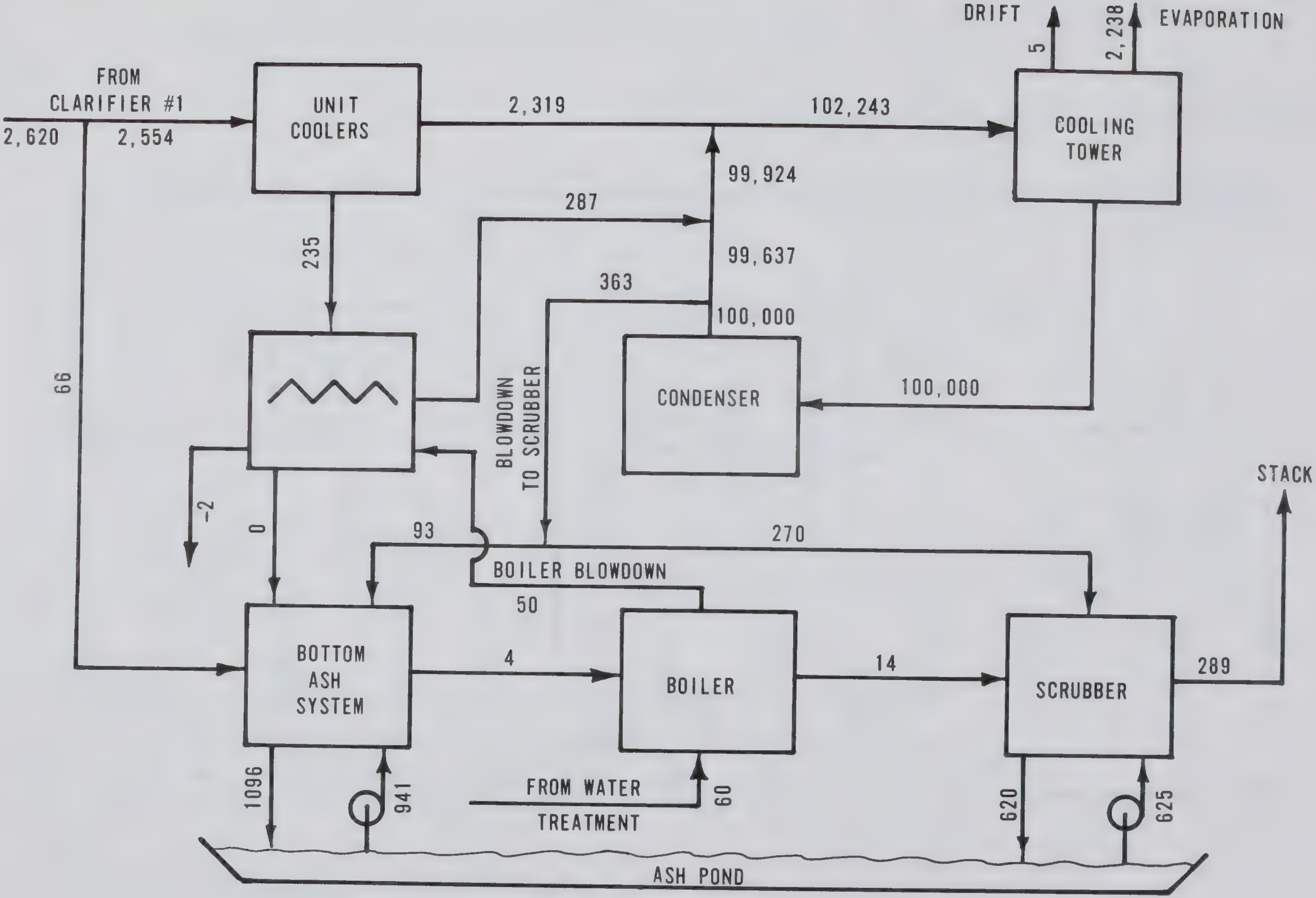
WINTER WATER BUDGET FOR GENERATING UNIT #3 AND #4
(VALUES ARE GPM)

FIGURE 8-22



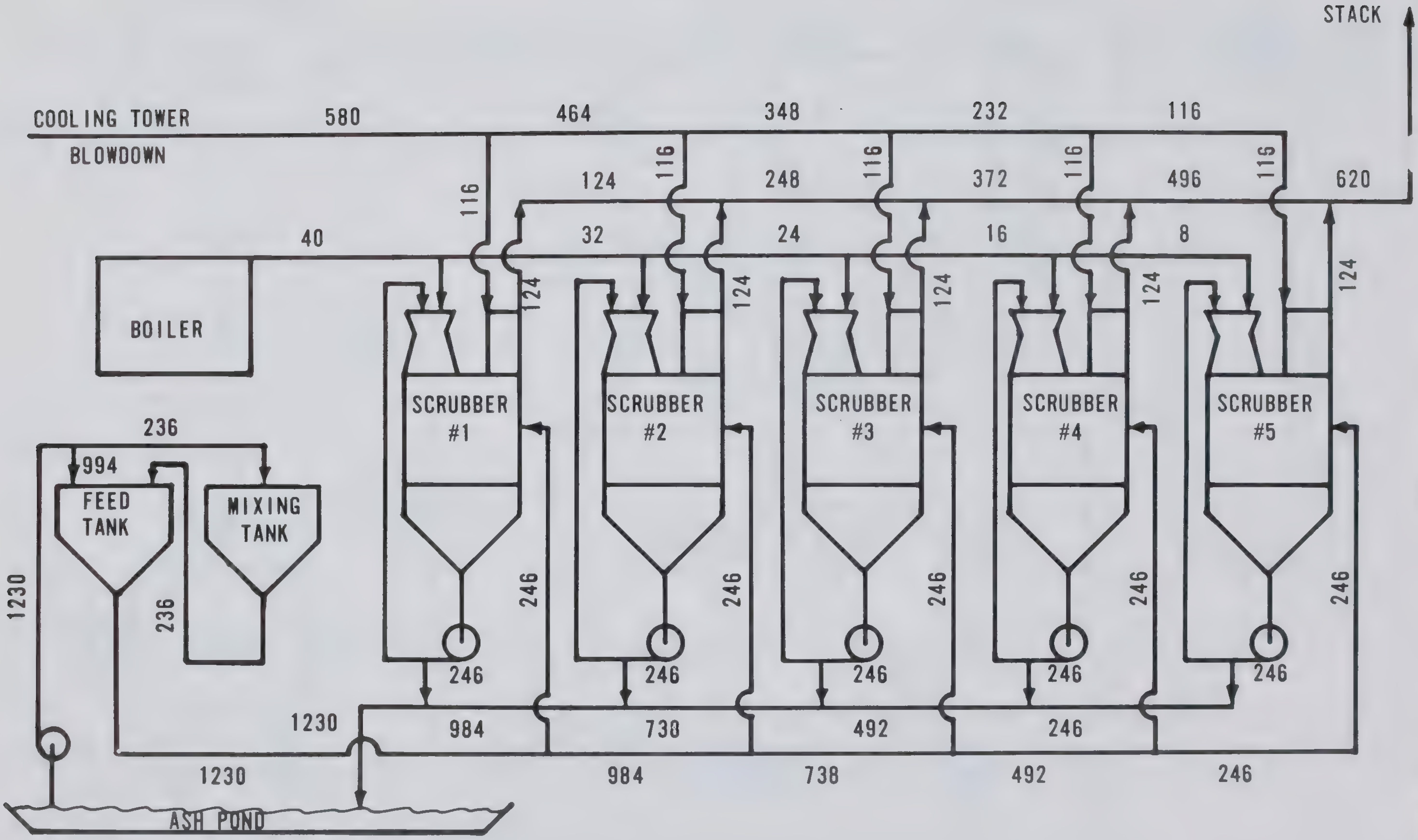
DETAILED WINTER WATER BUDGET FOR GENERATING UNIT #3 OR #4
(VALUES ARE GPM)

FIGURE 8-23



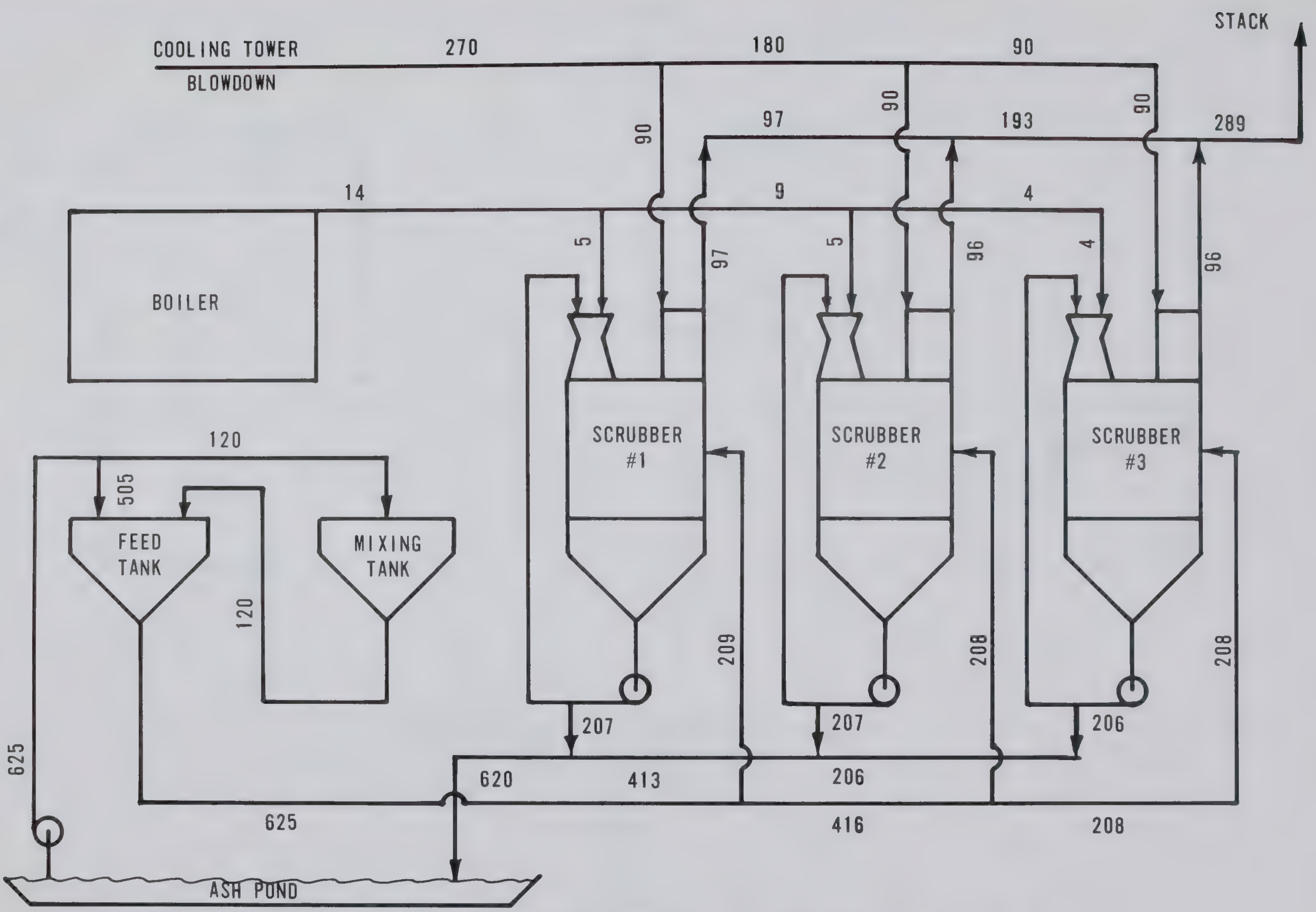
PROJECTED DETAILED WINTER WATER BUDGET FOR GENERATING UNIT #1 OR #2
(VALUES ARE GPM)

FIGURE 8-24



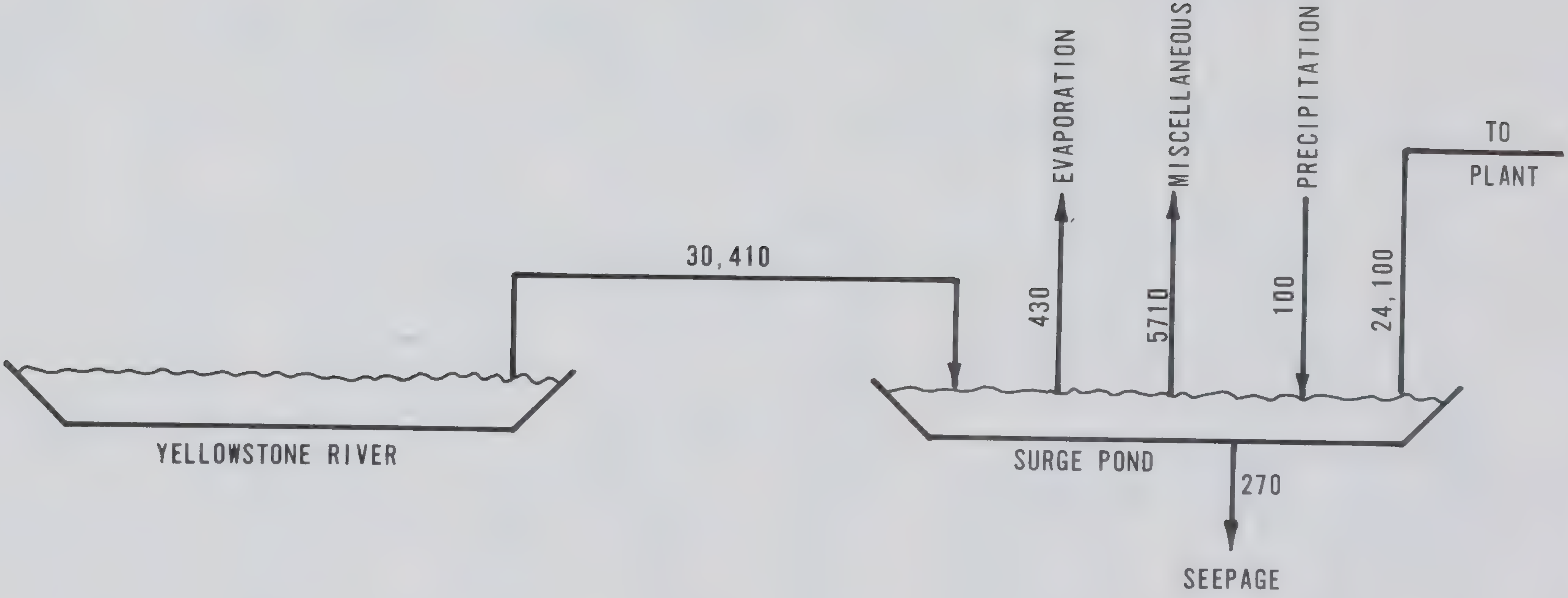
WINTER WATER BALANCE FOR SCRUBBERS FOR GENERATING UNIT #3 OR #4
(All Values are GPM)

FIGURE 8-25



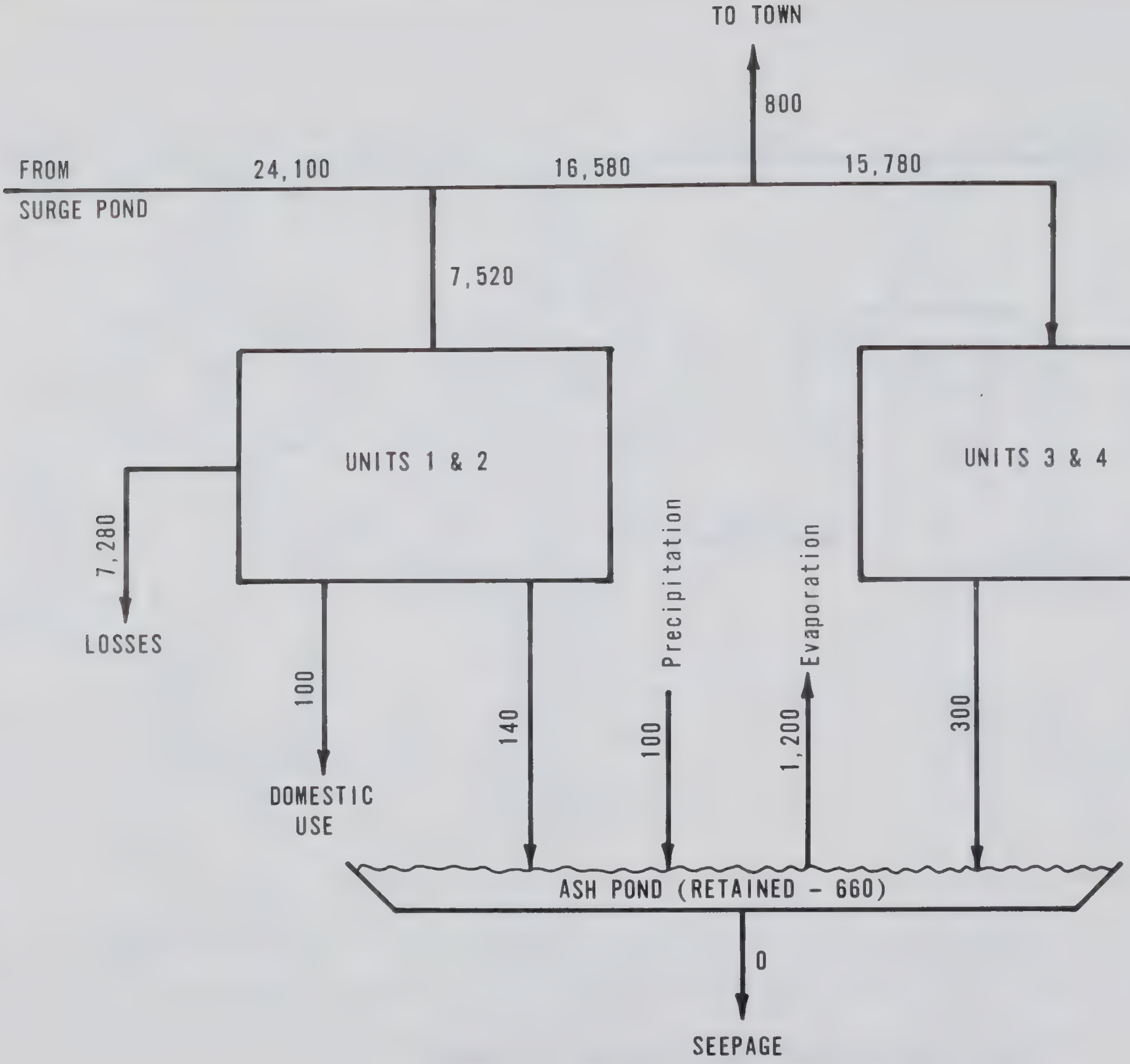
WINTER WATER BALANCE FOR SCRUBBERS FOR GENERATING UNIT #1 OR #2
(VALUES ARE GPM)

FIGURE 8-26



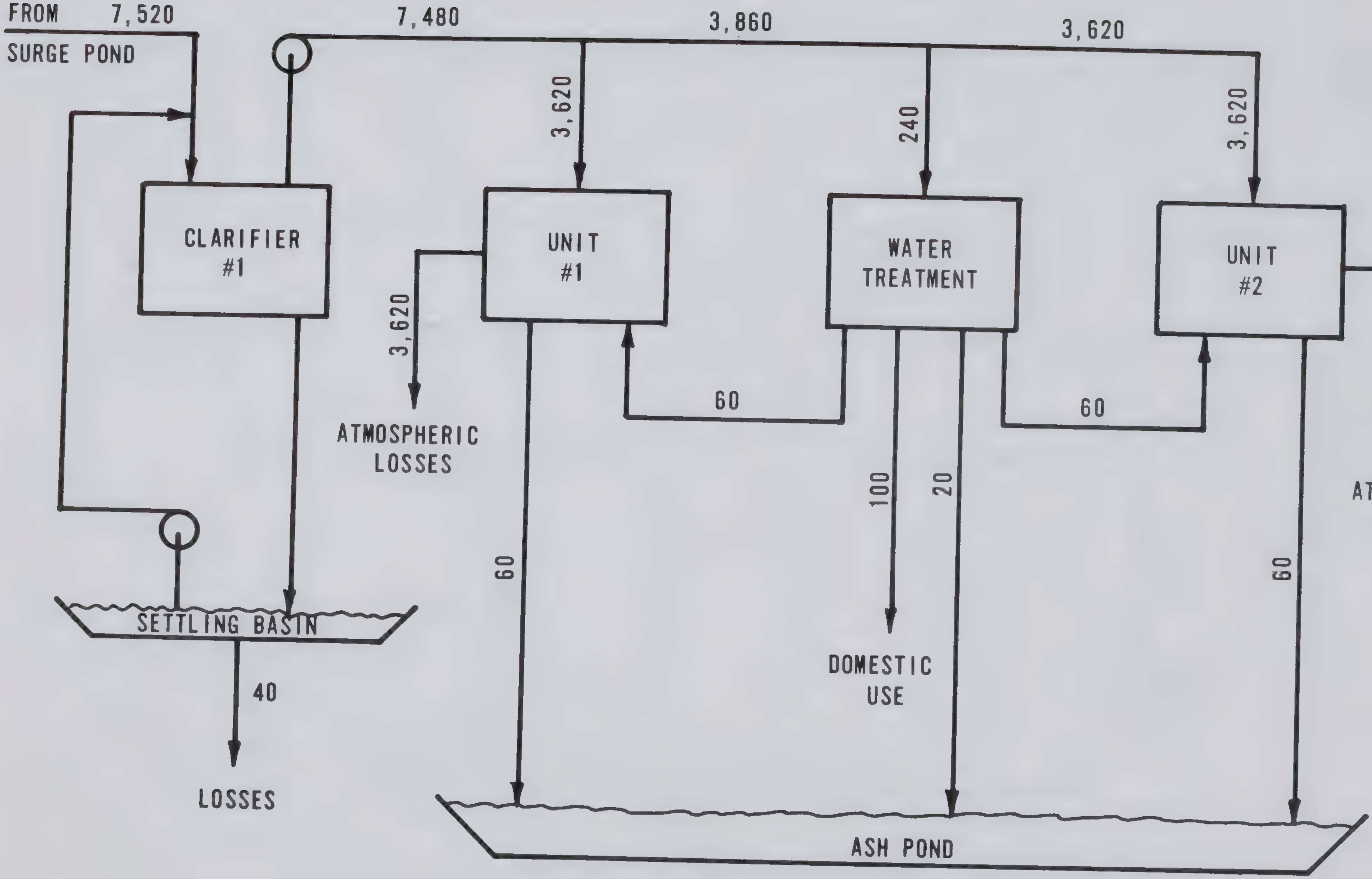
SUMMER WATER BUDGET FOR SURGE POND
(VALUES ARE GPM)

FIGURE 8-27



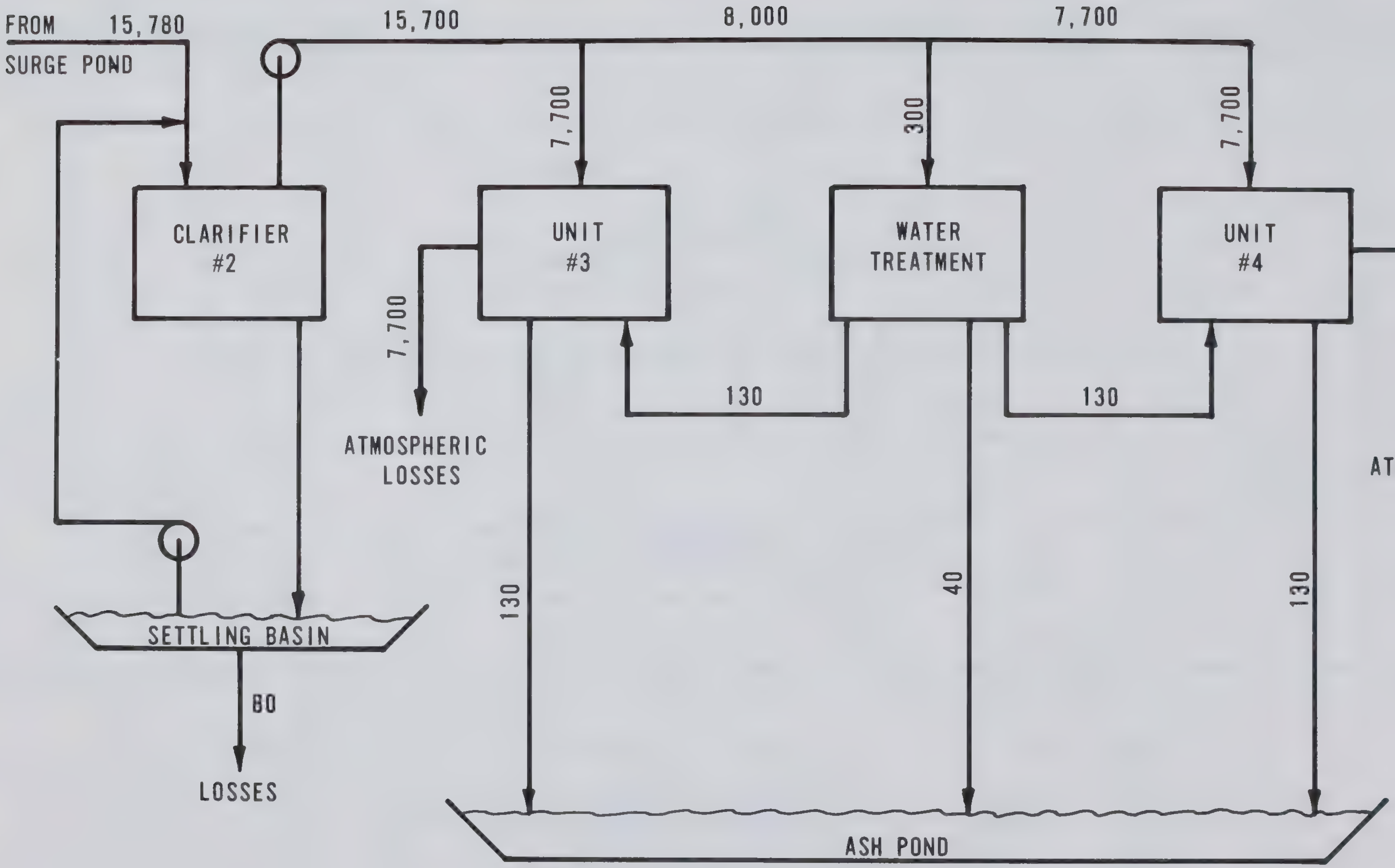
SUMMER WATER BUDGET FOR OVERALL COMPLEX
(VALUES ARE GPM)

FIGURE 8-28



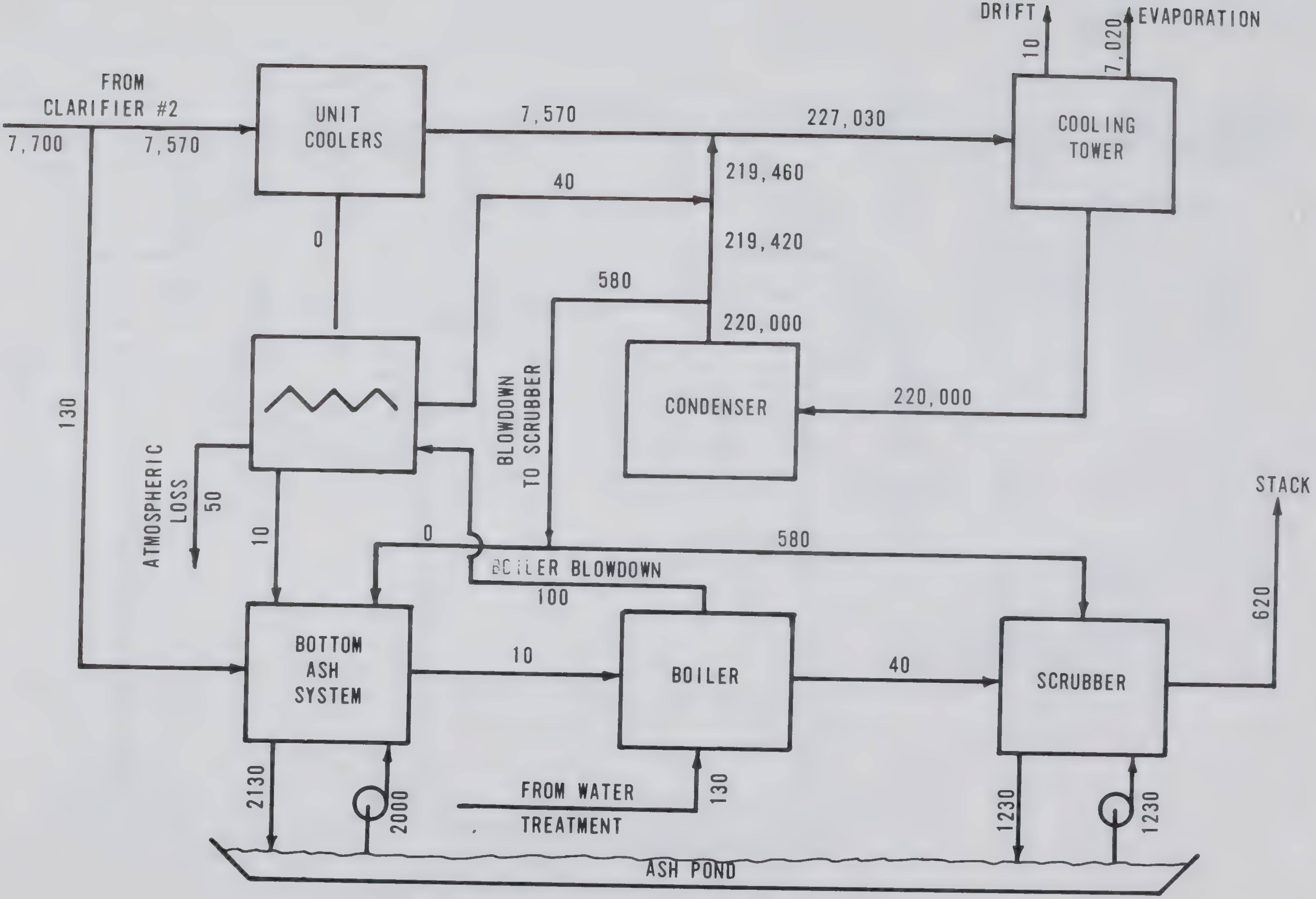
SUMMER WATER BUDGET FOR GENERATING UNIT #1 AND #2
(VALUES ARE GPM)

FIGURE 8-29

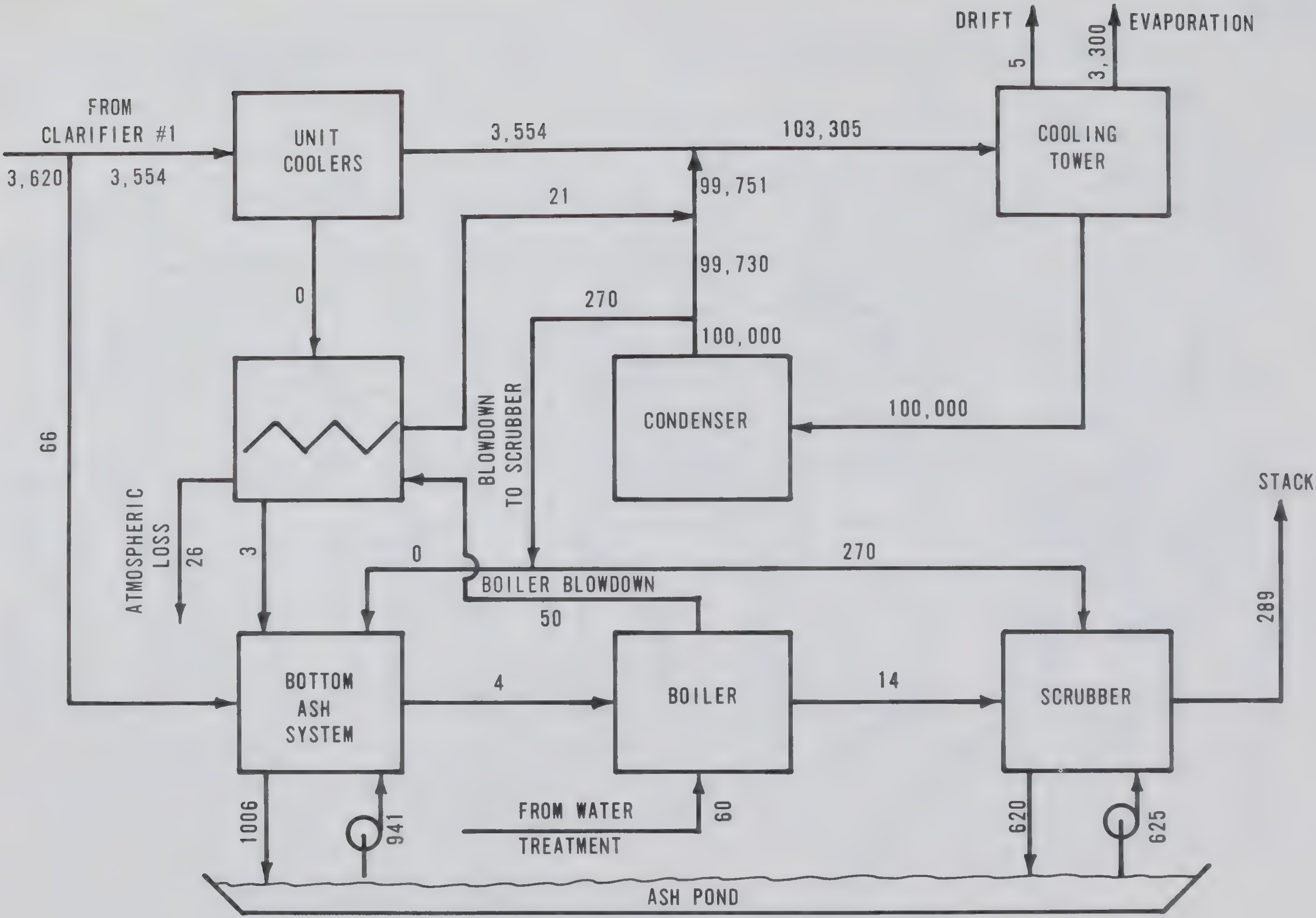


SUMMER WATER BUDGET FOR GENERATING UNIT #3 AND #4
(VALUES ARE GPM)

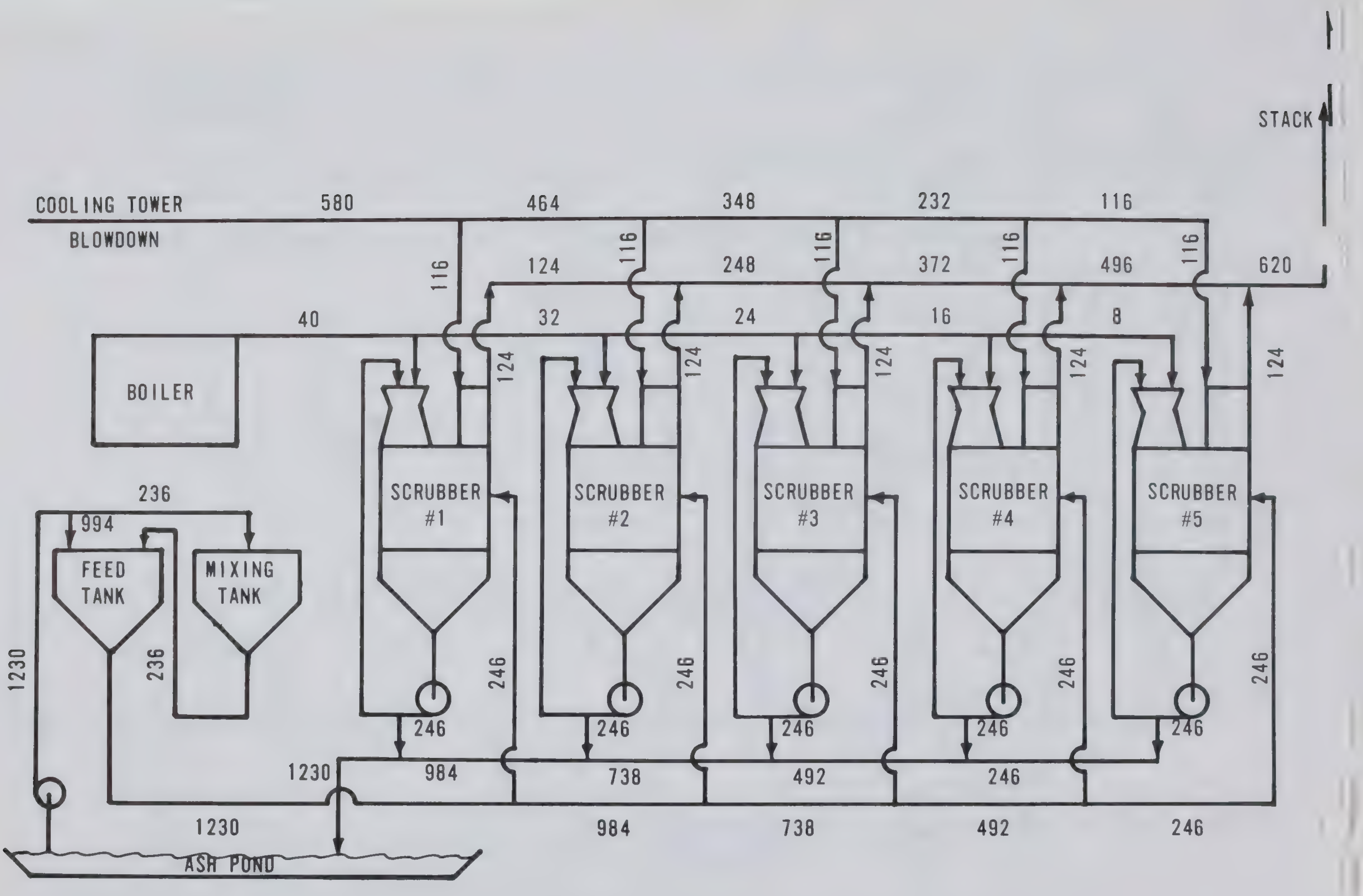
FIGURE 8-30



DETAILED SUMMER WATER BUDGET FOR GENERATING UNIT #3 OR #4
(ALL VALUES ARE GPM)
FIGURE 8-31

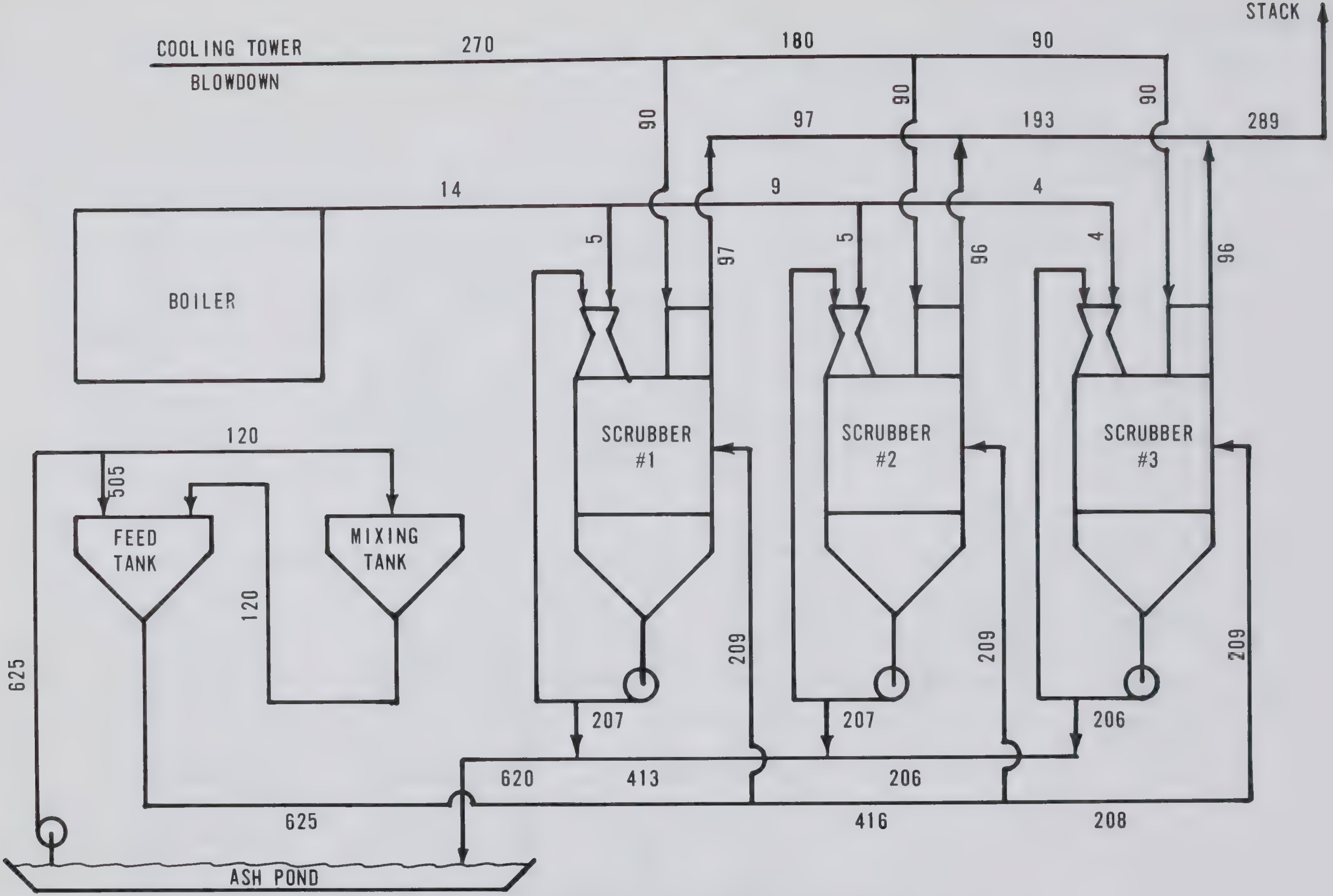


PROJECTED DETAILED SUMMER WATER BUDGET FOR GENERATING UNIT #1 OR #2
(VALUES ARE GPM)
FIGURE 8-32



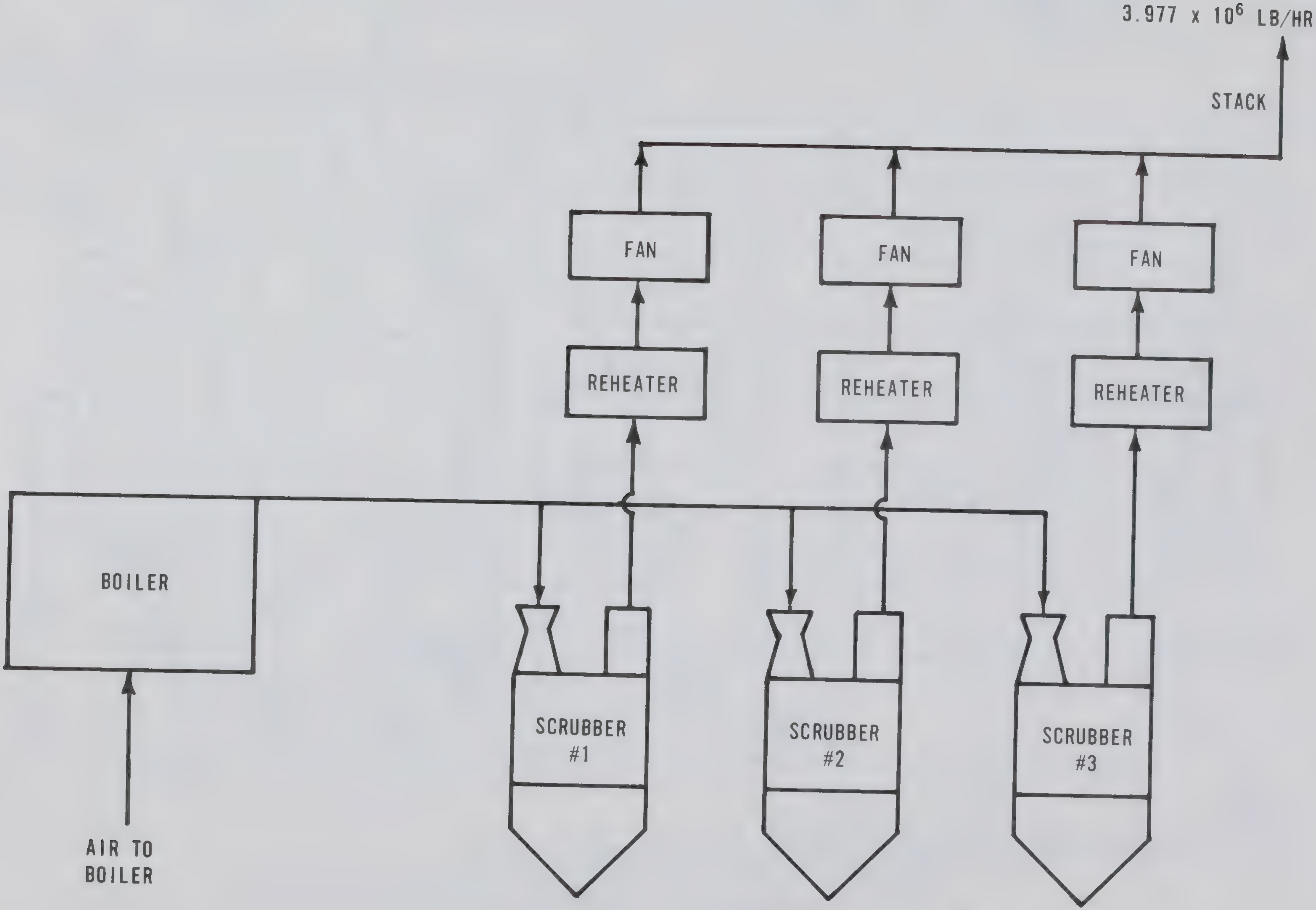
SUMMER WATER BALANCE FOR SCRUBBERS FOR GENERATING UNIT #3 OR #4
(VALUES ARE GPM)

FIGURE 8-33

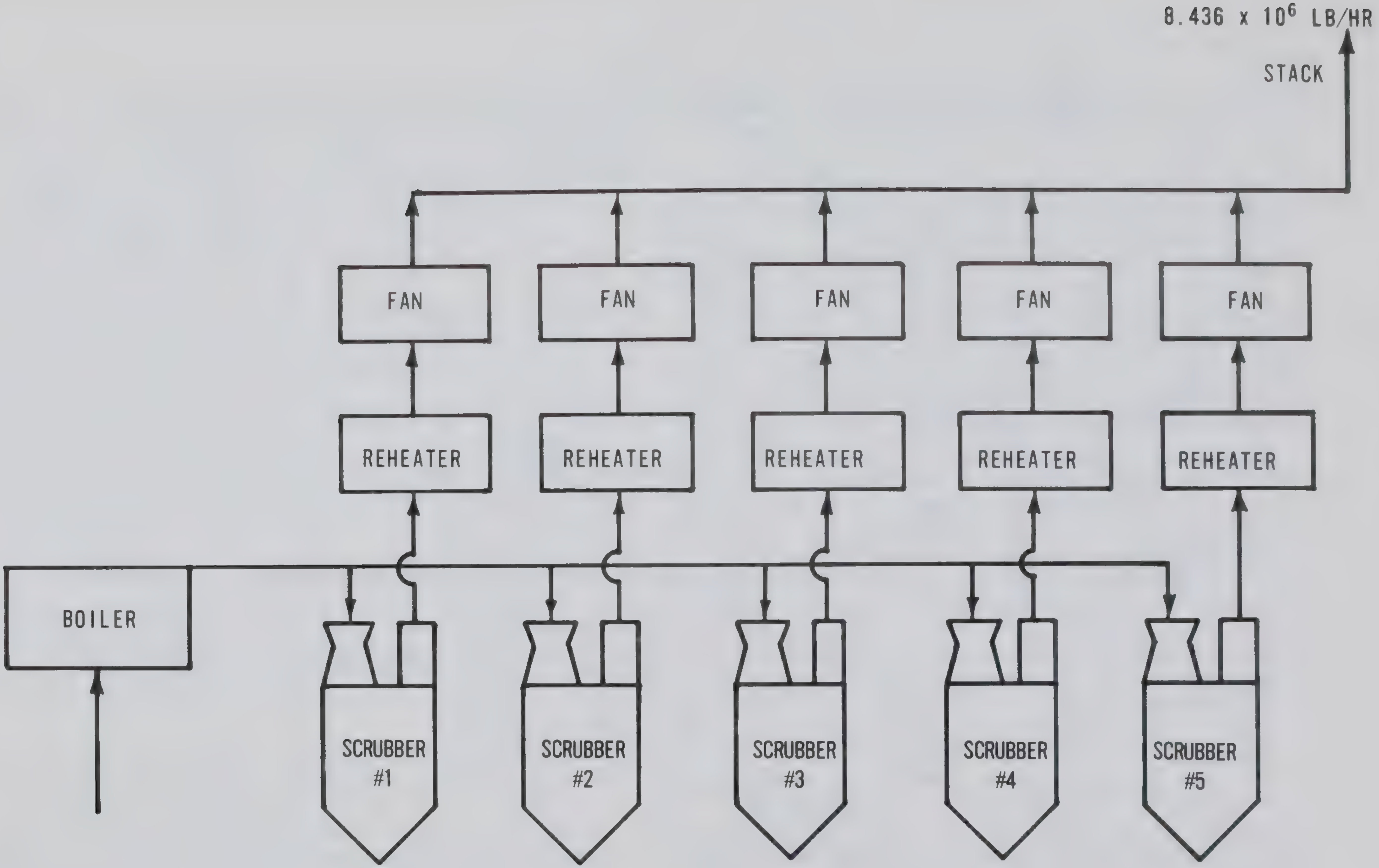


SUMMER WATER BALANCE FOR SCRUBBERS FOR GENERATING UNIT #1 OR #2
(VALUES ARE GPM)

FIGURE 8-34

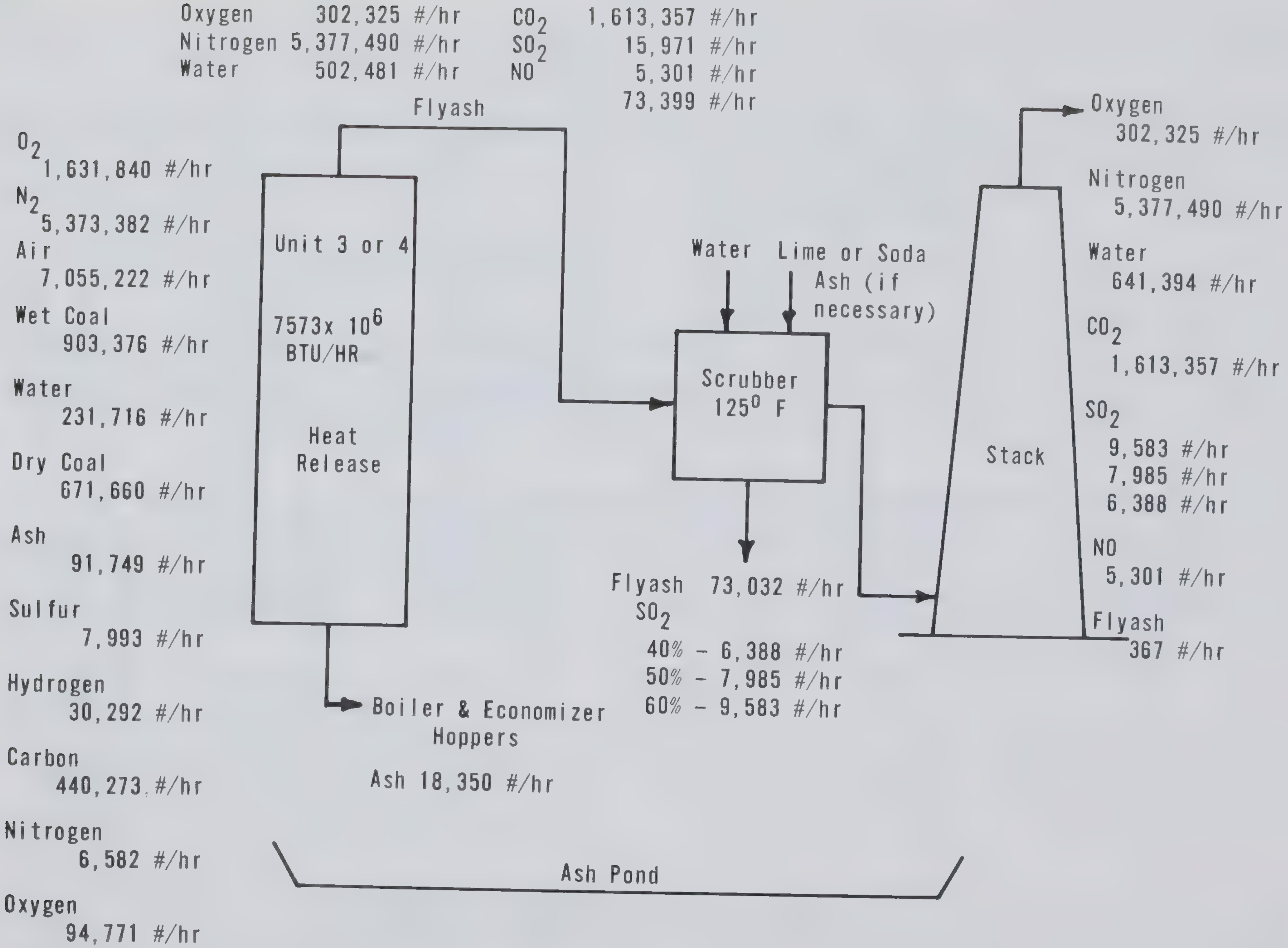


AIR FLOW BUDGET FOR GENERATING UNIT #1 OR #2
FIGURE 8-35



AIR FLOW BUDGET FOR GENERATING UNIT #3 OR #4

FIGURE 8-36



Unit Coal Flow Diagram

FIGURE 8-37

the final form of the sulfur salts. If limestone is used to maintain the alkalinity then insoluble salts would probably be formed, but if sodium carbonate (soda ash) is used water soluble salts will result. Neither the manufacturer or the applicant has indicated a need for this type of injection system.

Knowing the ultimate and proximate analysis for the coal (Section 8.3) and using 23% excess air, a stoicheometric balance was done to determine the quantity of air for combustion. Then, from the coal analysis and using the given assumptions, the flow rates for the given constituents were determined. From this figure it can be seen that all of the waste material which is not emitted via the stack would end up in the ash pond.

The amount of water vapor going up the stack would depend on the temperature in the scrubber. At 125°F, assuming the gases to be saturated, about 641,394 pounds per hour would be carried along with the rest of the flue gases.

8.5.4. Plant Chemical Analysis

The distribution of water treating chemicals should present no particular environmental problems since most of them will eventually end up in the ash pond as innoxious sulfates or chlorides.

Alum (which could be a number of materials but is probably $K_2SO_4 \cdot AL_2(SO_4)_3$ or $(NH_4)_2SO_4 \cdot AL_5(SO_4)_2$) would be added at the clarifiers as a coagulant to aid in silt removal. Some of it would be precipitated with the sludge, but the material is water soluble and much of it would end up in the ash pond via blowdown.

The polyelectrolyte (a water soluble polymer) which is also added at the clarifiers as a coagulant aid would be consumed in much the same manner as alum but would probably be slowly oxidized in the water.

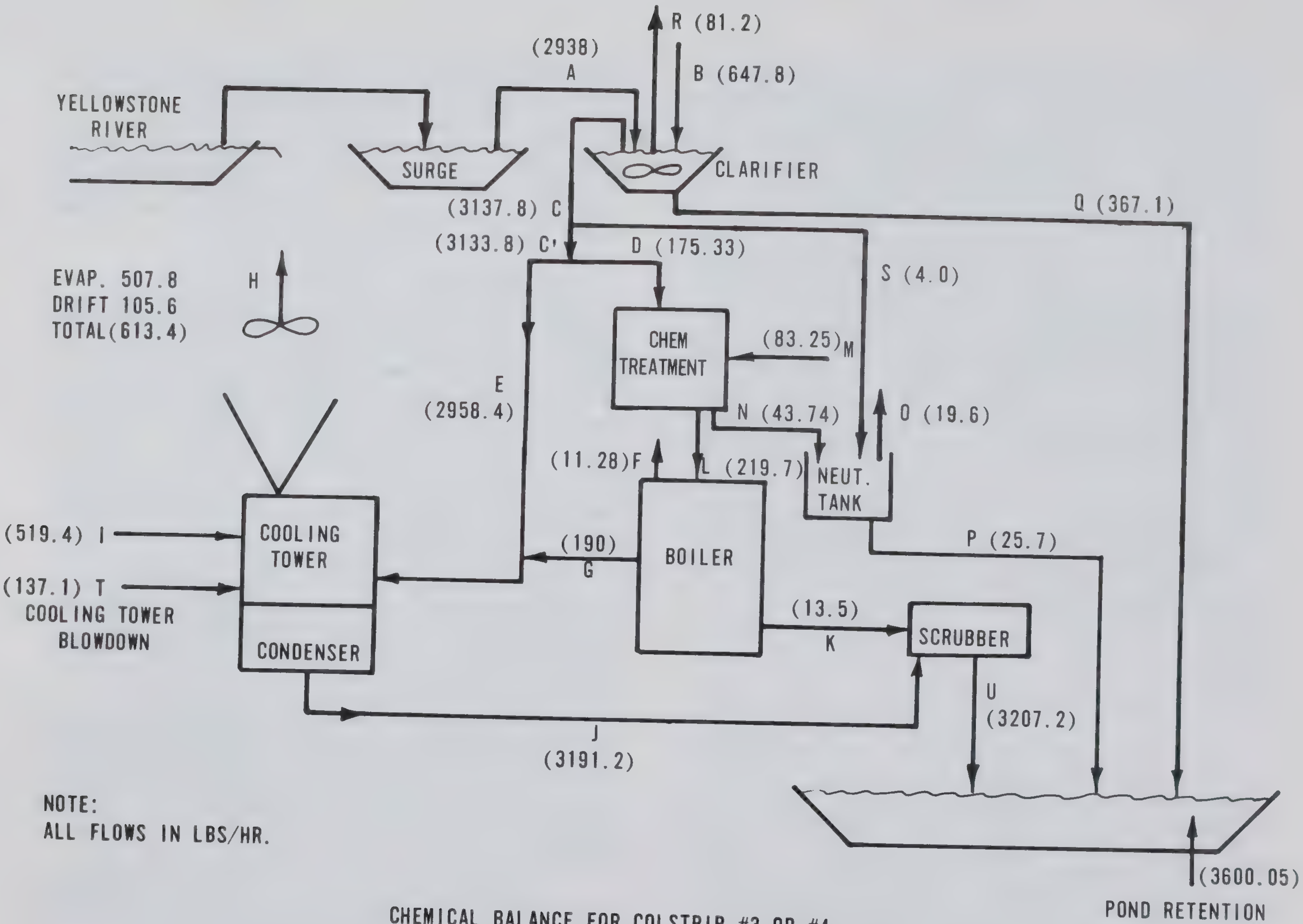
Chlorine would be added to the water at several locations in the plant to control biological growth. This is an oxidizing agent which reacts with organic matter and prevents growth. The excess would probably be reduced in the water to HCl which would react with inorganic constituents in the water, or be removed in the blowdown and eventually end up in the ash pond.

The sulfuric acid which is used in the circulating water system for control would likewise end up in the ash pond via the blowdown.

The sulfuric acid and sodium hydroxide used to regenerate the ion exchange resins would also end up in the ash pond. The sodium salt would be water soluble, however, and could present problems if there is seepage from the pond.

The two oxygen scavengers would be oxidized, the hydrazine to N_2 and H_2O and the sodium sulfite to the sulfate which would end up in the ash pond. The ammonia and phosphate used for pH control would probably be consumed in a similar manner.

Figure 8-38 is a chemical balance for either proposed Colstrip Unit 3 or 4. All the flows are given in pounds per hour. The values in parenthesis beside each letter indicate the total chem-



NOTE:
ALL FLOWS IN LBS/HR.

CHEMICAL BALANCE FOR COLSTRIP #3 OR #4

FIGURE 8-38

ical flow at that point in the system. The corresponding Table 8-8 gives a detailed breakdown of the various chemicals and quantities of each chemical which comprise the total.

8.6. Engineering and Operating Capacity

The current plans of the Colstrip Project Management are to depreciate all of the units at Colstrip over a 37-year period after each unit startup and to operate the units for at least that long. Since these will be base load units, the plan of operation is to run them continuously at a high load level, utilizing smaller thermal plants and hydro plants in the system to accomodate changes or higher peaks in load. This would result in a high annual load factor for the Colstrip units. As time goes by, increased size and new technology may permit greater efficiencies in this type of generation and it would be less economical to run the older units at the high load factor. This means that as the years go by the Colstrip units would decrease their load factor.

The Federal Power Commission's Hydroelectric Power Evaluation contains a summary of operational costs for steam-electric fossil-fueled plants, based on a 30-year service life. In this report the FPC assumed that the units would be operated over a range of relatively high annual plant load factors through the first half of the service life, gradually decreasing to a minimum, with a lifetime average of 55% to 60%.

After an initial break-in period, the load factor for Units 3 and 4 is expected to be 80%. It should stay around this level until the successful break-in of the next base load units. Historical load factor data from companies such as Commonwealth Edison indicate that this value of load factor may be optimistic for the length of time considered. Further reductions would take place as other new resources come on line in the future and are cheaper to run. These other resources could be nuclear as well as coal.

If two prospectives hydro projects, Buffalo Rapids and Mountain Sheep-Pleasant Valley, are constructed, the combined output for MPC would be about 500 MW, but at a low load factor of about 40%. Therefore, it would be well adapted to accomodating changes in load, but would have minimal effect on the load factor of the Colstrip units. If no more hydro construction is authorized by the Federal Government, then gas turbine peaking units might be necessary to compliment the large steam-electric plants which would provide the bulk of the new energy for the system.

A rough projection of the load factor for Colstrip Units 3 and 4 as submitted by MPC is that it would be quite high, around 80%, for the first eight to ten years. The load factor would then decrease fairly consistently to about 40% by the year 2015. The planned average lifetime load factor is 65%.

The crew size for operating and maintaining proposed Units 3 and 4 is expected to peak in July of 1979 with a total of 92 men. This value may be a bit low but only time and experience would reveal the actual number. Surprisingly, this value should not decrease as most of the operating personnel would be needed to cycle the units for peaking purpose when they get older.

TABLE 8-8

CHEMICAL BALANCE FOR UNIT #3 or #4

FLOWS IN LBS/HR

	A	B	C	C^1	D	E	F	G	H	I
Ca	234.5		234.5	234.2	13.11	221.1		13.11	10.2	
Mg	78.5		78.5	78.4	4.4	74		4.4	3.4	
Na	229.4		229.4	229.1	12.82	216.3		29.7	10.6	
NH_3								.051	.051	
SO_4	683	86.65	770	769	43	726		108.2	57.7	499.6
Cl	36.7	1.42	38.13	38.1	2.1	36		2.4	2.55	19.6
HCO_3	764.6		676.8	675.9	37.8	638			16.1	
CO_2	621.8		540.6	539.9	30.2	509.7	11.28		507.8	
SiO_2	60.15		60.15	60.1	3.4	56.7		3.4	2.55	
PO_4								.081		
Suspended Solids	229.4									
Cl_2									2.44	
Alum		47.9								

TABLE 8-8 (Cont.)

FLOWS IN LBS/HR

	J	K	L	M	N	O	P	Q	R	S	T	U
Ca	224		13.11				.3			.3		224
Mg	7.5		4.4				.1			.1		75
Na	235.3		29.7	16.9			.29			.29		235.3
NH_3			.051	.051								
SO_4	1276.1		108.2	65.2			.95			.95		1276.1
Cl	55.45		2.4	.3			.04			.04		55.45
HCO_3	621.9	13.5	13.5		24.32		22	87.76		.84		635.4
CO_2	1.9		11.28		18.9	19.6	.7		81.2	.7		1.9
SiO_2	57.55		3.4				.05			.05		57.55
PO_4	.081		.081	.081								.081
Suspended Solids								229.4				
Cl_2	-2.44											
Alum				.49	.49		.49	47.9				

TABLE 8-8 (Cont.)

FLOWS IN LBS/HR

	J	K	L	M	N	O	P	Q	R	S	T	U
Polyelectrolyte				.051	.051		.051	2.04				
FC	.0093		.108	.091			.0013			.0013		.092
Cu	.166		.024	.022			3×10^{-5}			3×10^{-5}		.165
Zn	.053		.01	.01								.053
Sn	.0018		.0003	.0003								.0018
Cr	.002		.0008	.0008								.005
Ni	.00045		.00025	.00005			3×10^{-6}			3×10^{-6}		.00045
Mn	1×10^{-6}		1×10^{-6}	1×10^{-6}								1×10^{-6}
Mo	.0029		.001	.001								.003
CaO	538.1		28.5				.7			.7	29.1	538.1
Na_2CO_3	108										108	108
TOTAL	3191.2	13.5	219.7	83.25	43.74	19.6	25.7	367.1	81.2	4.0	137.1	3207.2

TABLE 8-8 (Cont.)

FLOWS IN LBS/HR

	A	B	C	C^1	D	E	F	G	H	I
Polyelectrolyte		2.04								
FC		.032	.032	.031	.0017	.03		.093		.003
Cu		.032	.032	.031	.0017	.03		.024		.112
Zn								.01		.043
Sn								.0003		.0015
Cr										.0013
Ni		.003	.003		.0002	.0033		.0025		.0009
Mn								1×10^{-6}		
Mo								.001		.0019
CaO		509.7	509.7	509	28.5	480.5		28.5		
Na_2CO_3										
TOTAL	2938	647.8	3137.8	3133.8	175.33	2958.4	11.28	190	613.4	519.4

Also, as the units get older, even more men might be required on the maintenance crew to keep up with the outages and repairs.

CHAPTER NINE Coal Mining Activities

Western Energy Company (WECO) would supply the coal to fire proposed Units 3 and 4 of the Colstrip steam generating plant system.

9.1. Mining Area

The coal would be stripped from the Rosebud Mine complex located adjacent to the power plant site. At present, WECO anticipates stripping only Rosebud seam coal and leaving the McKay seam intact. Thus, all reserve estimates contained herein consider only Rosebud coal unless otherwise specified.

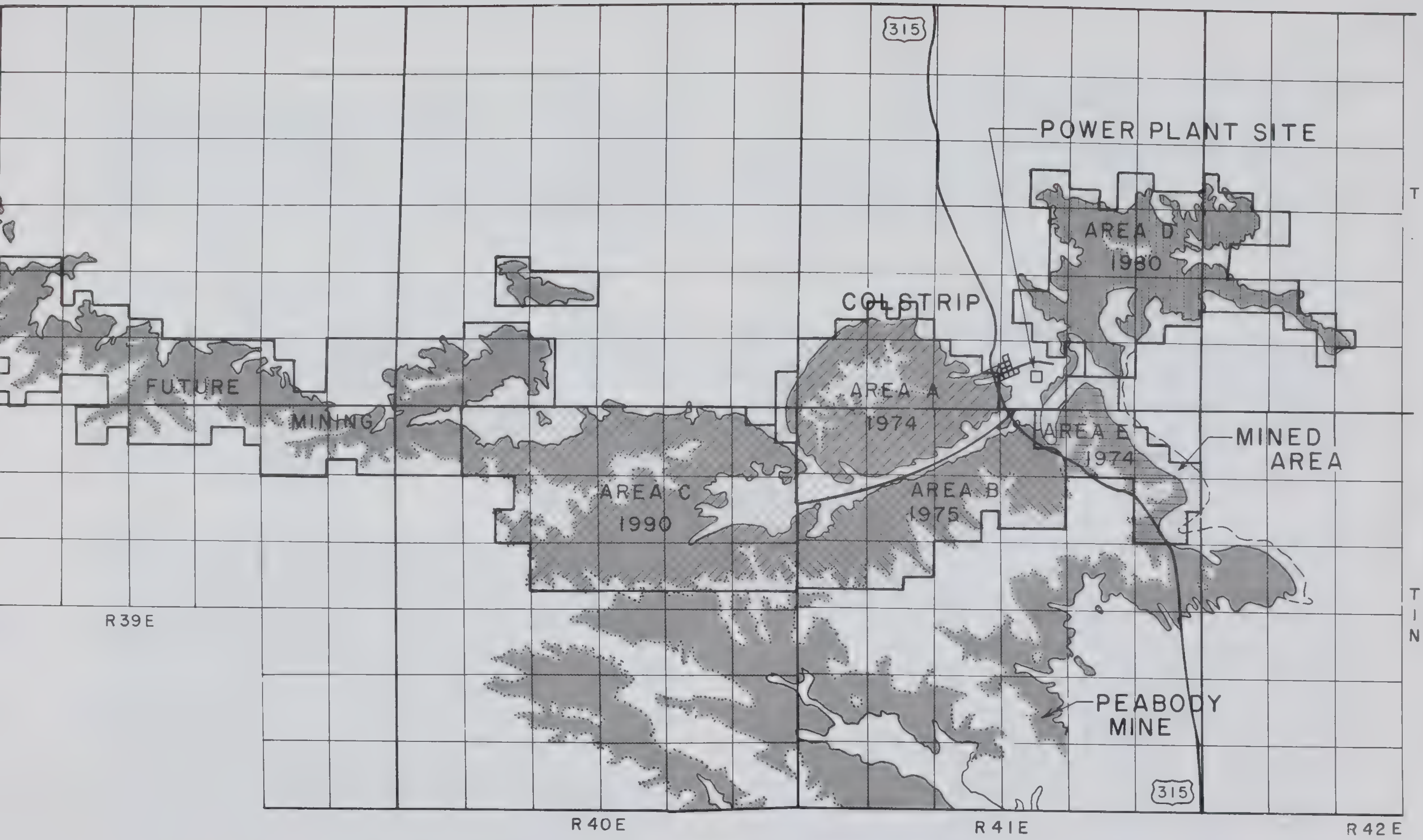
The Rosebud Mine is composed of five distinct areas (A, B, C, D, and E) and possibly a sixth (designated "future mining") (see Figure 9-1). Areas A and B are designated as sites to fulfill contractual obligations to Wisconsin Power and Light and Northern States Power Company, respectively. The acreage encompassed by these two areas totals approximately 6,193 acres. Coal for proposed Units 3 and 4 would be obtained from areas C, D and E for at least 30 years. Coal for Units 1 and 2, for the Corette Plant in Billings, and for spot contracts will also be obtained from areas C, D and E. Surface disturbance would amount to approximately 7,680 acres, 2,689 acres and 723 acres respectively for the three areas, for a total of approximately 11,092 acres. The estimated total reserves and the amount of coal committed from each area, assuming Units 3 and 4 are constructed, are shown in Table 9-1.

Colstrip Units 3 and 4 would each use approximately 885,000 to 903,000 pounds of coal per hour, or about 6.2 million tons per year depending on the coal's BTU content. Since the average thickness of the Rosebud seam is 25 feet, approximately 145 to 160 acres per year must be stripped in order to provide that tonnage.

The mined area could be reduced if coal from the McKay seam were also recovered. The McKay seam averages eight feet in thickness and generally underlies the Rosebud seam over most of the area. For example, in Area E over 12 million tons of McKay coal lie under less than 150 feet of overburden and are considered strippable. Proven strippable reserves of McKay coal underlying the other areas have not yet been calculated.

WECO proposes to leave the McKay seam intact at the Rosebud Mine indefinitely, claiming that the seam is not marketable "in the usual course of trade" as defined by the Coal Conservation Act (Section 50-1401 et seq., R.C.M. 1947), and thus that non-removal does not constitute waste. The Department of State Lands, which administers this act, agrees that in 1974 the McKay seam at the WECO Mine does not fall into the category of coal that is fit for sale in the usual course of trade. This does not mean that the coal is unuseable or could not be sold at some time in the future; however, the marketing of this coal would require more effort than would be expended in normal marketing channels.

One of the major reasons for believing that WECO's McKay coal could be marketed was that Peabody Coal Company sells McKay coal from its Big Sky Mine near Colstrip to Minnesota Power and



COLSTRIP COAL DEPOSIT—ROSEBUD SEAM
(MATSON & BLUMER 1973)

〰 - Limit of Rosebud
┈ - 150 Ft. Overburden Limit

FIGURE 9-1

TABLE 9-1

TOTAL COAL RESERVES AND COMMITTED RESERVES OF ROSEBUD MINE

Area	Year of Mining Commencement	Estimated Total Reserves-Tons (Overburden 0-150 ft.)	Committed Reserves-Tons (Assuming Units 3 & 4)
A	1974	109,905,000	109,905,000 (+ 28,095,000 from either B or C)
B	1975	164,203,000	100,000,000
C	1990	422,000,000	104,000,000
D	1983	119,000,000	119,000,000
E	1974	32,000,000	23,000,000

(Graving 1974)

Light. However, this in itself is not conclusive evidence of marketability, since it appears that the chemical makeup of the two coals is somewhat different (especially in iron and sodium content) and that Peabody McKay coal does cause slagging problems periodically in the boilers of a power plant designed to utilize it. It is also not certain that Peabody could market its McKay coal at this time were contractual commitments not previously made.

The high sulfur content of the McKay coal (average sulfur content = 1.25%) does not make it the most attractive western coal. In fact, SO_2 emission standards may make it necessary to blend McKay coal with a coal having a lesser sulfur content, such as Rosebud, depending on the emission control efficiency of the equipment involved. While blending of different coals is a common occurrence in eastern states, there is substantial industry concern with using a blend of these two particular coals because of the variation in the chemical and physical characteristics.

It would be theoretically possible for WECO to mine and stockpile the McKay coal until a buyer is located. However, the physical and environmental hazards associated with stockpiling, such as fire, water pollution and coal break-down, apparently outweigh the impacts at present of allowing the McKay seam to remain intact, especially when it is uncertain how long the stockpile would remain.

Montana Power Company is exploring the possibility of modifying the boilers and pollution control equipment on the proposed Units 3 and 4 to utilize McKay coal. The initial step is a test burn at the Corette Plant to quantify the ash characteristics. A possible second step would be to test burn several Rosebud-McKay blends, which would meet state air quality standards, to examine the effects on the boiler system.

9.2. Coal Mining Requirements

Reclamation, as defined in Montana, is a process which begins the day a mine is anticipated and which is completed only when the land is back in full-time productive use after mining. The steps in the reclamation process are presented in Table 9-2.

Table 9-2

RECLAMATION PROCESS

1) Inventory Resources
2) Conduct Analysis and Reach Subsequent Decision as to Reclaimability (Issuance or non-issuance of permit)
3) Stockpile Topsoil
4) Remove Overburden and Sort
5) Remove Coal
6) Place Sorted Overburden and Topsoil
7) Prepare Overburden and Topsoil
8) Seed and/or Plant Vegetation

9) Protect Vegetation

10) Manage and Use Land

(Morris 1974a)

9.2.1. Preplanning

The first step is a preplanning resources inventory which includes an overburden analysis and surveys of wildlife, soils and soil chemistry, vegetation, hydrology and any exceptional, special, critical or unique areas as defined by the so-called selective denial section of the Montana Strip Mining and Reclamation Act (Section 50-1034 et seq., R.C.M. 1947). As these surveys are completed, they are analyzed with reclamation feasibility in mind. If the site is considered reclaimable under the law and possesses none of the selective denial characteristics, the mining and reclamation plan is then designed to best meet the general provisions of the reclamation law and the special problems presented by that specific mine site.

The Montana Strip Mining and Reclamation Act requires that specific information be provided only for the area of land affected by the current year's permit. Therefore, detailed preplanning information is generally received only on a year-to-year basis and the problem situations over the life of the mine, such as toxic overburden layers, may not necessarily be anticipated in advance. Such problems will be handled as they are revealed and the mining and reclamation plan altered accordingly or the area deleted from mining.

The 1974 Montana State Legislature enacted a bill known as the Strip Mine Siting Act (Section 50-1601 et seq., R.C.M. 1947) which is intended to insure that a mine is not located in an area which cannot be reclaimed and that substantial financial commitments are not made by a company before that determination is made. General preplanning data for the anticipated life of the mine is required by this law. However, the Rosebud Mine, being an existing mine as defined by Chapter 16, is exempt from the provisions of the law unless a new mining area is determined, sometime in the future, to constitute a new mine.

9.2.2. Mining Method

WECO uses a method of mining known as area strip mining. In this type of mining generally an initial trench or box cut is made through the overburden to expose the coal. As the overburden is removed, it is thrown backwards onto the land behind the direction of mining to form the initial spoil piles. After the overburden is removed, the coal seam is taken. Subsequent cuts are made parallel to the original cut with the overburden being thrown back (backfilling) into the open trench left by the previous cut. The final cut leaves an open trench bounded on one side by the backfilled previous cut and on the other by a steep-sided face referred to as the final highwall which is as high as the sum of the overburden and coal removed.

The Montana Strip Mining and Reclamation Act

(Section 50-1034 et seq., R.C.M. 1947) and the pursuant rules and regulations specify strict standards for the mining plan and method of operations utilized by operators conducting area strip mining, such as WECO.

The method of mining affects the way in which reclamation is carried out. For example, only two ramp roads per mile of active pit are allowed unless a special problem arises and the Department of State Lands approves a modification. Ramp roads must remain at an overall 7% or steeper grade. These requirements minimize disturbance while maintaining safety and reclamation concurrent with the progression of mining.

The Rosebud Mine operations allow economical mining and comply with the provisions of the reclamation law. Preceding each cut or any mining associated disturbance, all available and usable topsoil and subsoil are removed by large tractor-scrapers and either stockpiled for future use or immediately spread on previously mined and regraded spoils. Topsoil stockpiles are located where they will not be disturbed by mining or rehandled until being replaced on regraded disturbances. Further, no unnecessary compaction or contamination of the topsoil is allowed, although planting of an annual or perennial crop may be required to stabilize the stockpile.

After topsoil removal, the overburden material may be drilled and blasted (during the day unless an emergency situation arises) to fracture and loosen the consolidated materials. Usually 24 holes on a 25 to 30-foot grid are blasted at one time. The resultant sound can be heard for a radius of at least 4,000 feet and the ground shock felt within a radius of approximately 10,000 feet from the center of the blast.

Following drilling and blasting, a stripping machine, either a dragline or shovel, moves through the area, removing overburden and casting the spoil into the adjacent mined out cut. In some cases the stripping machine does not have the capacity to handle the overburden depths, and scrapers are used to remove a portion.

At this point, also, if a toxic layer of overburden has been identified in the preplanning inventory, it is separated and buried at an appropriate depth during the regrading of the spoils material. For example, the Department of State Lands has determined that clay layers in Area E of WECO's mine are undesirable for concentrated placement in the top eight feet of regraded overburden or on the pit floor. Therefore, these layers will be segregated and buried in the middle of the regraded spoils.

After overburden removal, the uncovered coal is normally drilled and blasted. A shovel loads the coal into tractor-trailor units, which deliver it to the load out facilities.

WECO will maintain buffer zones of at least 100 feet from all streams, property lines, highways and areas deleted from the permit area by the Department of State Lands. Special permission would have to be obtained from that Department prior to any mining related disturbances of those zones, and only in extreme cases would such permission be granted.

The above steps constitute the generalized mining plan at Colstrip. As higher overburden depths are reached, new equipment and draglines come into use. Factors other than the equipment and handling procedures will also change. Furthermore, mining plans for each pit differ because of depth and shape of the coal seam, overburden problems, and other features.

WECO will have three active pits at the Rosebud Mine, each having a somewhat different plan and none using the idealized plan of exactly parallel cuts of precisely the same length. For example, mining for the first three years in Area E of the Rosebud Mine (Boyd et al. 1974) is designed for the lower overburden depth areas and to accommodate the stripping shovel-loading shovel-passing requirements. As shown on Figure 9-2, during the first year mining is concentrated in the southeast part of Area E. The pits do not enter the adjacent federal coal land for which lease applications are still pending with the Bureau of Land Management. Two short box cuts are provided for in the entry and turn around areas.

The second and third mining years are scheduled around the northeast and northwest perimeter following the former open pit configuration. Figure 9-2 shows two designated machine passing zones; the sharp northeast corner of Area E could also be used for passing.

The designated zones are designed to have a full pit width of coal for the 1050-B shovel movement and a one-half pit width spoil pullback area for the 550-B shovel movement. These zones will move with the second and third year stripping progressions. In addition to their passing function, they will provide in-pit storage of 276,000 tons of coal.

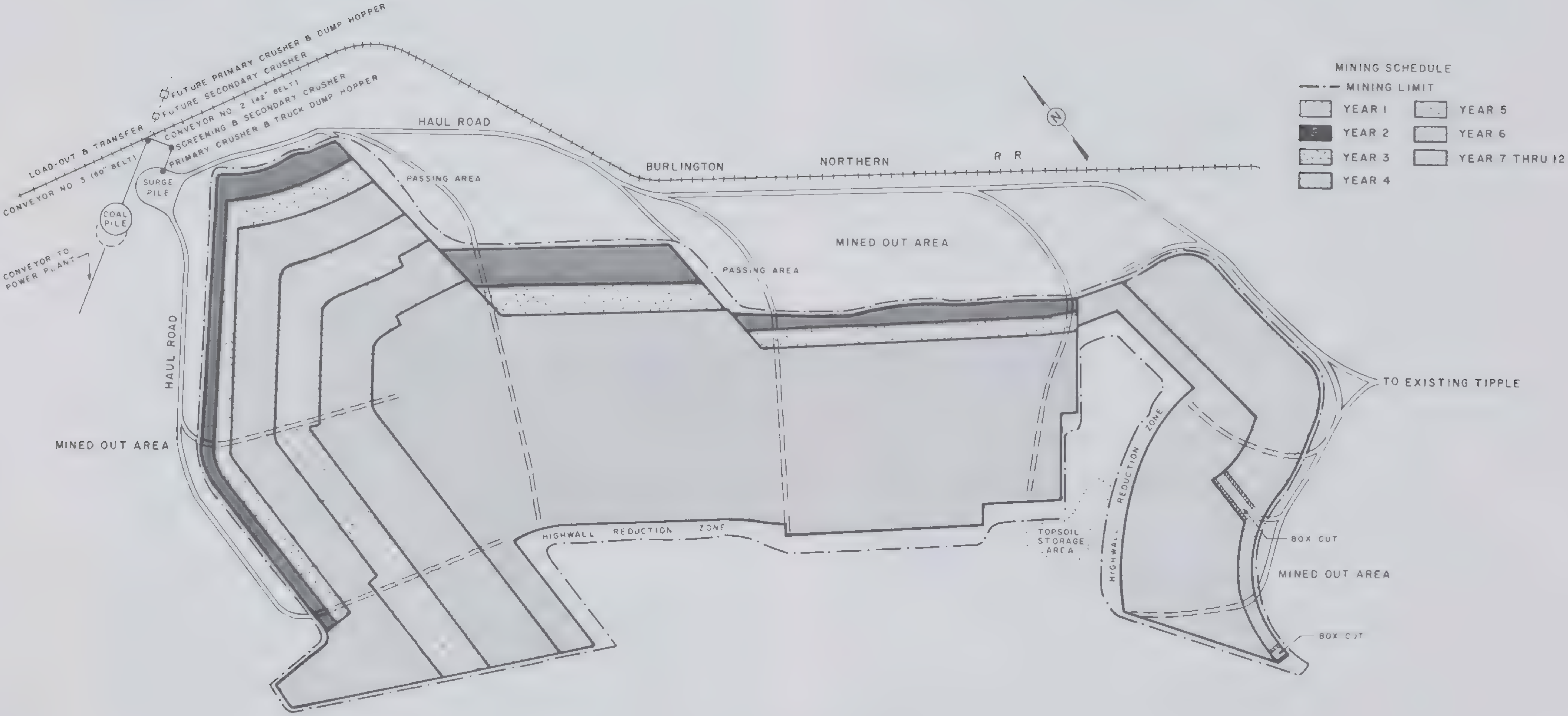
After the initial three years, a new 60-cubic yard capacity dragline is to be the main stripping unit. The proposed dragline pits are approximately one mile long and either straight or with outside curves. Ramp entrances are provided in the middle and at either end of the pits. This arrangement allows stripping from the center ramp each way to minimize interference between the stripping and coal loading operations.

A summary of the overburden volumes and recoverable coal tonnages scheduled for mining in Area E are:

Table 9-3

Mining Area E
Overburden Volumes and Recoverable Coal Tonnages
(Boyd et al, 1974)

Year	Acres	Recoverable Coal Tons (000's)	Stripping BCY (bank cubic yards) (000's)	Ratio BCY (bank cubic yards) Per Ton
Mined with Present Equipment				
1	75.09	3,000	8,820	2.94
2	79.35	3,000	8,651	2.88
3	79.47	3,000	10,158	3.38
Mined with New Equipment				
4	79.84	3,000	10,098	3.37
5	80.98	3,000	12,478	4.16
6	81.14	3,000	15,072	5.02
7-12	493.14	18,000	89,912	5.00
Total	969.01	36,000	155,188	4.31



MINING PLAN FOR AREA E

FIGURE 9-2

The overburden removal sequence for Area E is:

1) Scrapers remove the topsoil material to storage areas or to graded spoil areas. During the first three mining years, they will also remove additional overburden to leave a maximum of 50 feet for the shovel stripping. This material can be moved to spoil areas or to prepare level areas for the subsequent dragline operation.

2) The 1050-B shovel working alone removes the remaining overburden material at 6.2 million cubic yards per year, uncovering 3.0 million tons of coal. This machine is scheduled for the initial three mining years.

3) The 360-M dragline is scheduled for important auxiliary work in the first two years, including necessary cleanup of the existing pit and preparation of the box cuts and passing areas. The scrapers and dozers will be required to provide some assistance for the dragline work.

4) After the 1050-B is moved to Area D, stripping will be done by a new 60-cubic yard Marion 8050-14 or equivalent. It will strip the remaining coal in the mining plan. The deep cover area will require dozing of overburden into the pit for rehandling with the dragline.

All of the annual stripping volumes assigned to the machines are within their established or estimated capacities. The 60-cubic yard dragline reaches its rated capacity during the third operating year.

A summary of the major equipment scheduled for the fourth through the twelfth mining year is:

1 - Marion dragline, type 8050-14 or equivalent; 60 cubic yard bucket; 325 foot boom.

1 - Bucyrus Erie rotary blast hole drill, type 45-R or equivalent.

1 - Bucyrus Erie coal loader, 195-13 or equivalent; 16 cubic yard dipper.

3 - Coal haulage trucks, 120 ton capacity.

5 - Dozers (four type D-9 and one type D-8).

1 - Road grader, Cat. 16 or equivalent.

9.2.3. Alternative Means of Supplying Coal

There are several alternative methods of providing coal to the power plant units other than adjacent surface mining.

One alternative is to provide coal from a strip mine in some other locale, either in-state or out-of-state. The result of this alternative would still be massive disruption of the surface elsewhere.

A second alternative would be to provide coal from an underground mine, either adjacent to the power plant or at some other locale.

The major advantage of underground mining is the minimal removal and disturbance of surface strata. At Colstrip, underground mining of the relatively shallow Rosebud and McKay seams would probably create severe subsidence or underground caving. However, mining of deeper seams in that area would probably be feasible if proper technology were utilized.

Today's equipment for underground mining was developed for coal seams less than 10 feet in thickness. However, new technology in underground mining could increase recovery from the current average of 57% to more than 90% of the coal seam.

One such method, the longwall mining method, uses a shearer or plow which is raked across the face of the coal seam underground, and the coal is transported out of the mine. Behind the plow, about 10 feet behind the coal face, is a row of powerful jacks capable of lifting 400 tons each. As the plow advances forward, these jacks support the shallow roof of overburden above the coal seam until such time as they can be lowered and moved forward. This process allows the mining to progress under a shield of steel plates supported by the jacks. The roof above the mined out area behind the row of jacks is collapsed in such a way that the rock fills the void but does not affect the ground surface above. Further, no coal is lost through leaving pillars to provide roof support. (McCormick 1974).

Underground mining has some disadvantages in comparison with surface mining. Development of an underground mine often requires the expenditure of up to six times more capital than the development of a surface mine. Surface mining achieves a productivity of 200 tons per man shift, whereas a maximum productivity for underground mining normally would be 20 tons per man shift. Consequently, underground mining requires more workers. Because there is currently a shortage of underground mining personnel in Montana, the development of an underground mine would require the importation of substantial numbers of qualified people or the training of now unemployed Montanans.

9.3. Reclamation Method

9.3.1. Site Preparation

Reclamation must be kept current with the mining operation. Grading and backfilling will be no more than two spoil ridges behind the pit being worked at WECO unless exceptions are specifically allowed by the Department of State Lands to insure better reclamation.

Grading must be accomplished to the approximate original contour of the land with no unauthorized depressions allowed to remain. As required by law, all Rosebud Mine slopes will be graded to a 5:1 (five horizontal to one vertical) contour or flatter except all final highwalls; these will be graded to a 20°, or approximately 3:1, slope or flatter. If necessary, spoil materials will be end hauled from the initial box cut spoils to provide the necessary fill for the final cut.

Pre-mining elevations of the land affected will not be restored because of the loss of material in the form of coal. However, removal of the overburden causes unconsolidation which increases its volume, phenomenon known as the "swell factor". At Colstrip the swell factor runs between 20% and 25%. This means, for example, that if 50 feet of overburden material is stripped, that overburden, when replaced after removal of the 25 foot coal seam, would constitute 62.5 feet of fill material, resulting in a net initial loss of elevation of approximately 12.5 feet. Eventually, however, the material will begin to compact, and the land surface will settle slowly.

Following grading, salvaged topsoil is respread on the spoil surfaces which are left roughened to prevent slippage between topsoil and spoil surfaces.

Specific site preparatory surface manipulation is allowed only on a case by case basis. At WECO gouging is currently permitted with aerial seeding only on perimeter outslopes and highwall reduction areas where erosion may be a problem. No other form of manipulation is utilized.

Before or as the topsoil is respread, soil tests are again done to determine deficiencies. Fertilizer or soil supplements may be added but only after a review by State reclamation specialists. These supplements are usually added only during the first year of revegetation, but in special cases may be used during the second.

9.3.2. Revegetation

Following the completion of grading and topsoil redistribution, seeding and planting must take place during the first opportune season. The seeding generally is accomplished by drill seeding on the contour, while the planting may be by transplants, sod plugs or other approved methods.

The reclamation law requires establishment of a self-sustaining, permanent, diverse vegetative cover of predominantly native species. To accomplish this purpose, WECO currently is seeding a mixture which includes the following plant species.

Table 9-4

Reclamation Species Used by WECO

- Crested wheatgrass
- Thickspike wheatgrass
- Western wheatgrass
- Slender wheatgrass
- Lincoln bromegrass
- Orchard grass
- Green needlegrass
- Alfalfa
- Prairie sandreed
- Basin wildrye
- Indian ricegrass
- Nuttall alkaligrass
- Cicer milkvetch
- Sainfoin
- Four wing saltbush
- Big sagebrush
- Rubber rabbitbrush
- Yellow sweetclover
- Greasewood
- Skunkbush sumac
- Scadscale saltbush
- Nuttall saltbush
- Woods rose
- Ponderosa pine
- Plains cottonwood
- Snowberry

Tall wheatgrass
Golden current
Blue grama
Needle and thread

As seed becomes available for other native species or research proves their potential for revegetation, other species will be added to the mixture.

Sweet clover, field peas or a hybrid grass may be planted, if needed, as one-year field crops to improve the upper soil layer. Trees and shrubs will probably be planted as root pads or seedlings in addition to their seeds being included in the mixture.

WECO may irrigate reclaimed areas for the first year and possibly the second if needed for vegetation establishment. They will also fence reclaimed areas if premature use threatens vegetative establishment.

9.3.3. Reclamation Costs

WECO has estimated that it will cost the company $1,000.00 per acre to reclaim the surface mined land at Colstrip and that the total cost to date of efforts to reclaim the old Burlington-Northern spoils adjacent to the mine site has been $600.00 per acre. In 1972, WECO mined 5,500.774.64 tons of coal and spent $66,991.29 in reclamation costs, or approximately 1.2¢ per ton.

The bonding level, however, is based on what it would currently cost the State, in compliance with all aspects of the 1973 reclamation law, to complete reclamation. Therefore, WECO is being bonded at an average of $1,925.00 per acre. Mining level disturbance (overburden and coal removal areas, spoil deposition areas) reclamation costs are estimated at $2,200.00 per acre; facility areas (tipple, rails, crusher, buildings) at $3,300.00 per acre; associated disturbance (access roads, haul roads) at $200.00 per acre; and ramp roads at $1,000.00 per acre. As more information and research results become available and as costs fluctuate, reclamation costs and bonding levels will change to reflect those fluctuations.

9.4. Associated Mining

Construction of Units 3 and 4 and associated facilities would directly require mining of other minerals besides coal. These include gravel and scoria (clinker) for road beds and other related construction and rip rap for the dam, pipeline and intake area. Each pit opened by this type of mining would disrupt only a small acreage proportional to that of the coal mine. However, each pit must be regraded, retopsoiled and revegetated after closure under the provisions of either the Hard Rock Act (Section 50-1201 et seq., R.C.M. 1947) or the Open Cut Act (Section 50-1501 et seq., R.C.M. 1947)./1

Construction of the power plants would also require mining of coal as part of the construction process. The potential site for Units 3 and 4 is underlain by an average of 8.9 feet of McKay coal or approximately 157,890 tons. This coal must be removed to provide a solid base for the power plants' foundation. Although all of the coal scheduled for removal does not have good structural and chemical properties, WECO will use good quality coal for test burn purposes for any prospective customer. The remainder will be used as a base for the Rosebud coal stockpiles for the generating units.

The site will be stripped of overburden and coal using caterpillars, tractors and scrapers. One half will be stripped at a time. The overburden from the first half will be placed on the second half. Once the coal is excavated, the overburden will be placed back in the hole, and mining of the second half will proceed similarly. Following mining, material will be taken from orphan spoils on the permitted area to replace the loss of elevation from removal of the coal. Both areas will then be graded and the orphan spoil areas reseeded.

Construction of Units 3 and 4, the transmission lines and other associated facilities will indirectly cause mining of raw materials, throughout the nation and possibly the world. These include copper, iron, tungsten, bentonite, limestone, and many others needed to make and constitute the building or operating materials for the facility.

9.5. Conclusion

Surface mining of the magnitude needed to supply the power plants at Colstrip will have some obvious immediate effects. The land mined will be taken out of productive use until, and if, it is successfully reclaimed - an unknown period of time but at least several years. Wildlife dependent on the area for habitat will be displaced or eliminated from the area until, and if, reclamation is accomplished that satisfies the displaced habitat requirements. The ground water system, since both coal seams and the sandstone layers in the overburden are the major aquifers in the area, will be disrupted indefinitely. If the ground water flow established a new pattern the quality of the water may change due to flow through different strata.

It is difficult to ascertain whether or not the land intended to supply coal for Units 3 and 4 would be strip mined if the plants were not built. In all probability that coal would be sold for out-of-state contracts to fuel other plants.

FOOTNOTES

CHAPTER NINE

1. Since all applications for those minerals to this time have been under the Hard Rock Act, locations, details of the reclamation plan and so forth are confidential and cannot be discussed in detail (as provided by Section 50-1221 of Chapter 12).

CHAPTER TEN Colstrip Site Inventory and Analysis

10.1. Natural Environment

10.1.1. Meteorology

10.1.1.1. Climate

The climate of eastern Montana and the study area is determined to a large extent by the interaction of three major air masses with origins over the northern Pacific Ocean, the northern polar regions, and the Gulf of Mexico. The basic characteristics of these three air masses differ: the northern Pacific air is generally cool and moist; the polar air cold and dry; and the Gulf air warm and moist (Landsburg 1969). The relative influence on the study area weather of these air masses varies with season, with Gulf air tending to dominate in summer and polar air dominating in winter. This seasonal domination of the air masses together with the frontal activity generated by their mixing, produces the weather patterns in the study area (Missouri Basin 1969).

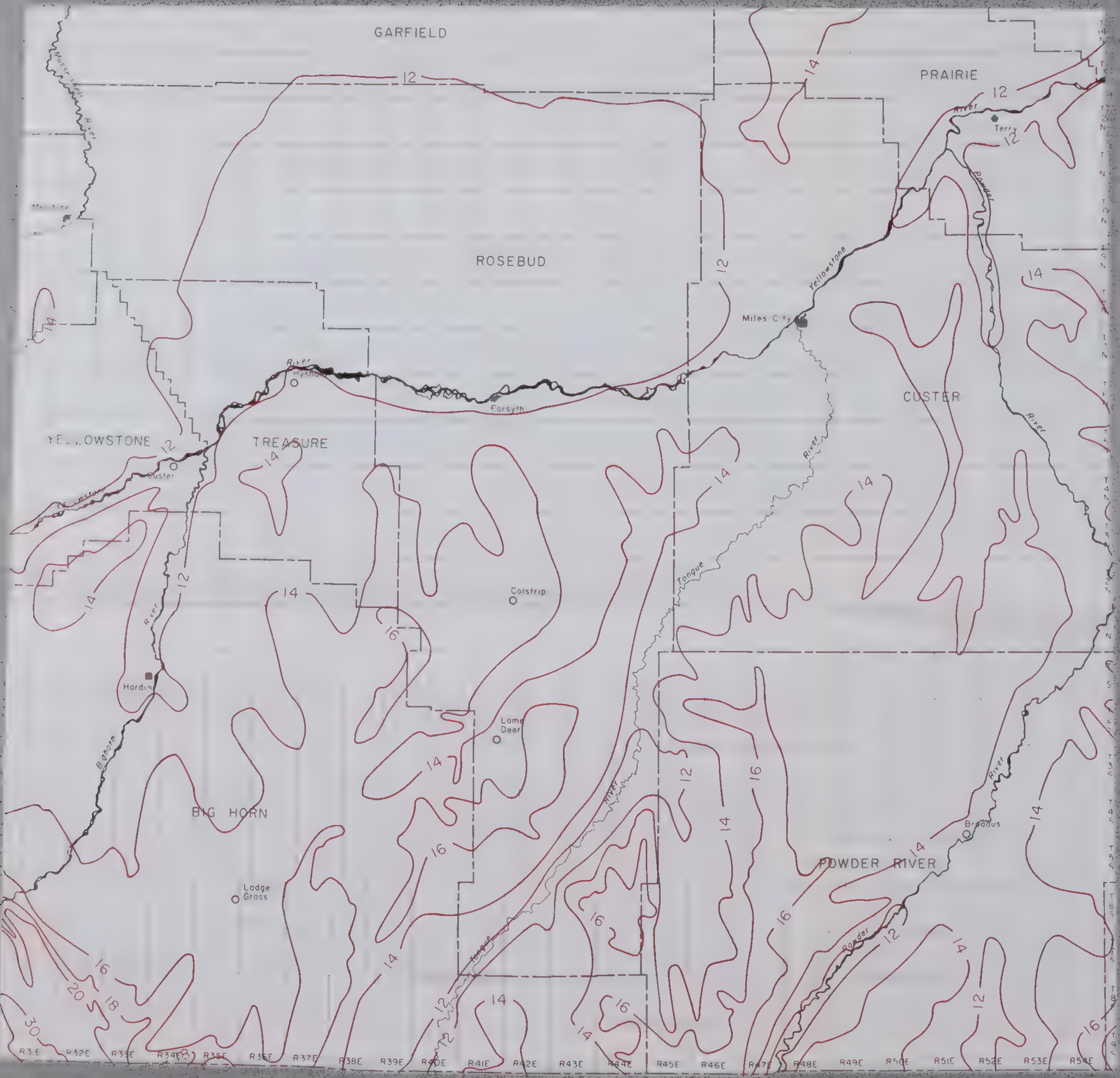
The location of the study area in relation to the origins of these three air masses is a factor in determining the area's climate. Air reaching eastern Montana from either the Gulf of Mexico or the northern Pacific Ocean must cross significant land areas. Pacific air must also cross two major mountain systems, the Cascades and the Rockies. As a consequence much of the precipitation associated with the original air masses occurs prior to reaching the study area. The temperatures of the original air masses are also modified by radiation and sensible heat exchanged with the ground surface. In general, because of the lack of major terrain barriers to polar and Gulf flow, these air masses, upon arrival in the study area, retain more of their original characteristics than the Pacific air.

Because of the modifying effects on the Pacific and Gulf air masses reaching the study area, the area's climate reflects continental characteristics: surface humidity is low; precipitation is light but variable, and is confined primarily to the warmer seasons of the year; daily temperature variations are large and temperature extremes are pronounced; and prevailing wind speeds are moderate.

The variation in average annual precipitation throughout the study area is shown on the "Average Annual Precipitation" map included in this section. Except for the Big Horn Mountain region in the extreme southwestern corner of the study area, total annual amounts of precipitation average from about 11 to 16 inches. Over 70% of the yearly precipitation total normally occurs during the April to September growing season, with a pronounced maximum occurring in the late spring-early summer months of May and June./1 Precipitation in the summer usually occurs as rain showers and is often associated with thunderstorm activity. More general rainfall is frequent during the late spring-early summer period and can also occur during September and October./1 Measureable Snowfall can generally be expected as late as May and as early as September./1 Some of the heaviest snowfalls in the study area have been recorded in March and April./2 Total annual snowfall throughout the study area ranges from about 30 to 50 inches./1

Recorded temperatures in the study area have

AVERAGE ANNUAL PRECIPITATION



ranged from greater than 110°F to less than -50°F (U.S. Department of Commerce 1965). Winters are generally cold, with the mean temperature in January, the coldest month of the year, about 20° F (U.S. Department of Commerce 1965). The coldest periods, during which temperatures may fall well below zero, are associated with the cold polar outbreaks and generally last two to four days (U.S. Department of Commerce 1971; U.S. Department of Commerce no date; U.S. Department of Commerce 1972c). A temperature of -65° F was recorded on January 13, 1888 at Fort Keogh near Miles City (U.S. Department of Commerce 1965). Summers are generally warm with mean temperatures in July, the warmest month, generally in the low 70's (U.S. Department of Commerce 1965), and mean maximum temperatures about 90°F (U.S. Department of Commerce 1971). Maximum recorded temperatures of 111° F have been reported for Miles City, Forsyth, and Hysham (U.S. Department of Commerce 1965).

The variation of average length of freeze-free season in the study area is shown on the following map "Average Length of Freeze Free Season"./3 The variation ranges from over 135 days along the Yellowstone River near Miles City to less than 90 days in the Big Horn Mountains. The average dates of the last spring and first fall freeze for selected locations are given in Table 10-1. The relatively long growing season, the warm summers, and the May-June precipitation maximum make agriculture viable in the arable portions of the study area.

Tables 2-6 located in Appendix A4 summarize the climatic data available for Colstrip. Included are the Climatological Summary for Colstrip published by the NOAA Weather Service and a summary of the one year of Colstrip relative humidity and temperature data measured and the resultant dew point and wet bulb temperatures calculated by Heimbach et al. (1974). Appendix A4 also contains hygrothermograph data (Table 7) as well as radiation and visibility measurements in the Colstrip area (Tables 8 and 9). Figures A7 and A8 in Appendix A4 summarize wind data collected at two sites near Colstrip.

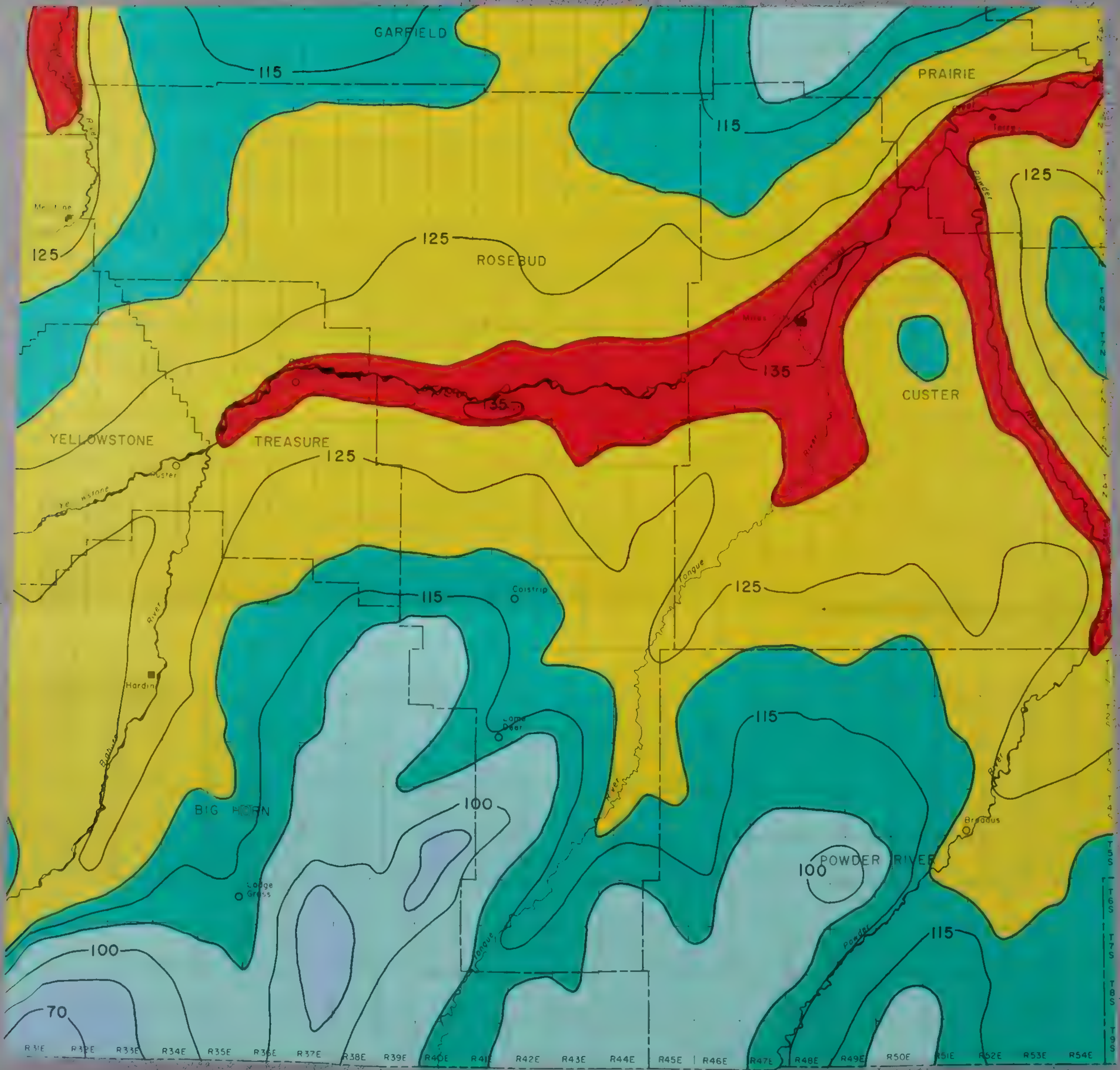
TABLE 10-1

	Mean Date of Last Spring Occurrence	Mean Date of First Fall Occurrence	Mean No. of Freeze-Free Days
Broadus	5-17	9-21	128
Busby	5-28	9-14	109
Forsyth 2E	5-19	9-26	130
Miles City	5-5	10-3	150
Melstone	5-16	9-23	129
Wyola	6-2	9-15	105

Source : Climatography of the U. S. No. 60-24
Climate of Montana, 1971

10.1.1.2. Severe Weather

Severe weather which may occur in the study area includes thunderstorms, hail, tornadoes, and strong winds. The incidence of thunderstorms at Colstrip is estimated to be about 20 to 30 days per year (U.S. Department of Commerce, no date), and the average at Miles City is 29 days per



AVERAGE LENGTH OF FREEZE FREE SEASON

🟦 50 to 90 days
🟦 90 to 110 days
🟩 110 to 120 days
🟨 120 to 130 days
🟥 130 days and longer

ISOLINE INTERVALS

20 days below 90
10 days 90 to 110
5 days thereafter

SOURCE Cooperative Extension Service,
Data Base Period 1921-1950

year. According to hail maps produced by Stout et al. (1968), the number of days in the study area with hail in an average twenty-year period ranges from 40 to 70. Both thunderstorms and hail storms are primarily confined to the summer months. Tornadoes occur infrequently in eastern Montana (U.S. Department of Commerce 1971), and incidences are "...generally short lived and much smaller than those of the midwest" (U.S. Department of Commerce, no date). No tornadoes occurred in Rosebud County from 1952 to 1972, and the number for the same period for counties adjacent to Rosebud were: Custer, 4; Powder River, 3; Big Horn, 2; and Treasure, 4 (Westinghouse 1973). Severe wind data is unavailable for the study area.4/ The fastest mile /5 reported for Billings during a 29-year period was 79 miles per hour from the northwest (U.S. Department of Commerce 1972a). The Climatological Summary for Colstrip states "... strong winds occasionally occur, but the incidence of these is not large."

10.1.1.3. Air Pollution Potential

Air pollution potential is directly related to the ability of the atmosphere to dilute and disperse pollutants. This dilution and dispersion ability is a function of three parameters: wind, atmospheric stability, and mixing depth. Wind acts in two primary modes in pollutant dispersal, the mean wind transports pollutants from the location of the source, and the turbulent fluctuations of the wind mix the pollutants with the surrounding environmental air. In general, higher wind speeds and greater turbulent wind fluctuations promote greater pollutant dilution and dispersal. Atmospheric stability is defined in terms of vertical atmospheric temperature structure and can either suppress or enhance turbulent wind fluctuations. Stable conditions suppress turbulence and hence pollutant dilution, while unstable conditions promote the opposite effect. Mixing depth defines the vertical extent of the volume of air available for pollutant dilution. Lower mixing depths generally mean less dilution and higher pollution potential./6 When dilution and dispersion ability is limited, air pollution potential will be high.

Meteorological data related to air pollution potential including various wind and temperature parameters were sampled at Colstrip by the Department of Earth Sciences of MSU during the period November 13, 1971 to November 12, 1972 (Super 1973). Continuous temperature and wind data were taken on a 300-foot tower, and vertical wind and temperature profiles were obtained using pilot balloons and aircraft flights, respectively. Part of the study related the Colstrip data to similar observations at surrounding weather stations during the sampled year. A comparison was made with sampled year of data for the nearby stations and longer periods (generally 10 years) of record to check the degree to which the sampled year was representative of the longer period. The following conclusion was reached:

> The overall conclusion to be drawn...(from the comparison)...is that the sampled year was rather typical of the longer term climatology at Colstrip. Seasonal and annual wind speeds and directions, surface temperatures, mixing depths, and Pasquill Stability Categories were all in reasonable agreement. Use of the sampled year to

represent long-term pollution patterns would therefore, generally result in acceptably accurate estimates (Heimbach et al. 1973, p.76).

Figures 10-1 through 10-7 summarize selected results from the one year of data collection.

A. Wind

The seasonal and annual wind roses for 307 feet above ground level (AGL) and 1053 feet AGL indicate that the predominate wind directions at Colstrip are westerly and northwesterly. The annual and seasonal mean wind speeds exceeded 10 miles per hour at both 307 and 1053 feet AGL.

Calm conditions in which wind speeds did not exceed two miles per hour (0.9 m/sec) occurred about 3% of the time annually.

B. Atmospheric Stability

Figure 10-5 shows the annual and seasonal distribution of Pasquill Stability Categories calculated using Atomic Energy Commission (AEC) lapse rate criteria and 59 feet (18m) and 294 feet (90m) tower temperatures./7 The frequent occurrence of the extremely stable category, prompted Super et al. (1973, p. 71) to note that (the frequency) "...does raise the suspicion that AEC lapse rate criteria used to estimate Pasquill Stability Categories might overestimate extremely stable conditions".

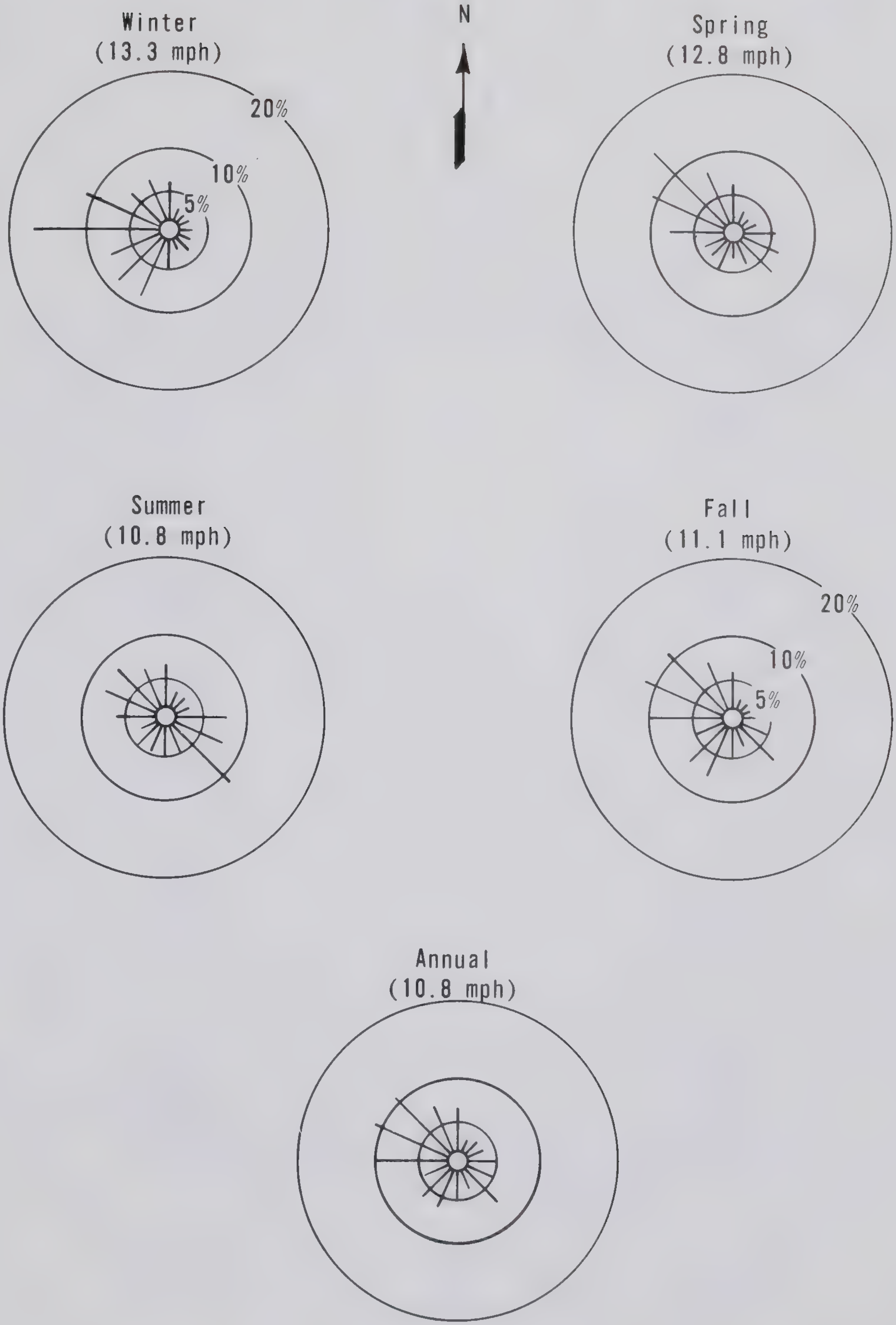
C. Mixing Depth

Super et al. (1973) reported that ground based temperature inversions and/or isothermal layers were present in all but two of the 169 near dawn temperature soundings. This indicates the absence of mixing depths extending to the ground during the near dawn hours at Colstrip. Figure 10-6 lists the frequencies of the top heights of the near dawn ground based inversions and/or isothermal layers by season. No inversion and/or isothermal layers were greater than 3000 feet thick, and for all seasons except winter, 50% of the layer thicknesses were less than 1000 feet. During the near dawn hours while these ground based stable layers exist, the ground level concentrations due to a buoyant elevated emission source would probably be kept low.

Figure 10-7 gives the frequency of maximum mixing depths derived from afternoon soundings by season. The mean seasonal and annual afternoon maximum mixing depths calculated using the data shown are: winter, 1400 feet (400m); spring, 7000 feet (2100m); summer, 9200 feet (2800m); fall, 3300 feet (1000m); and annual, 4300 feet (1300m)./8

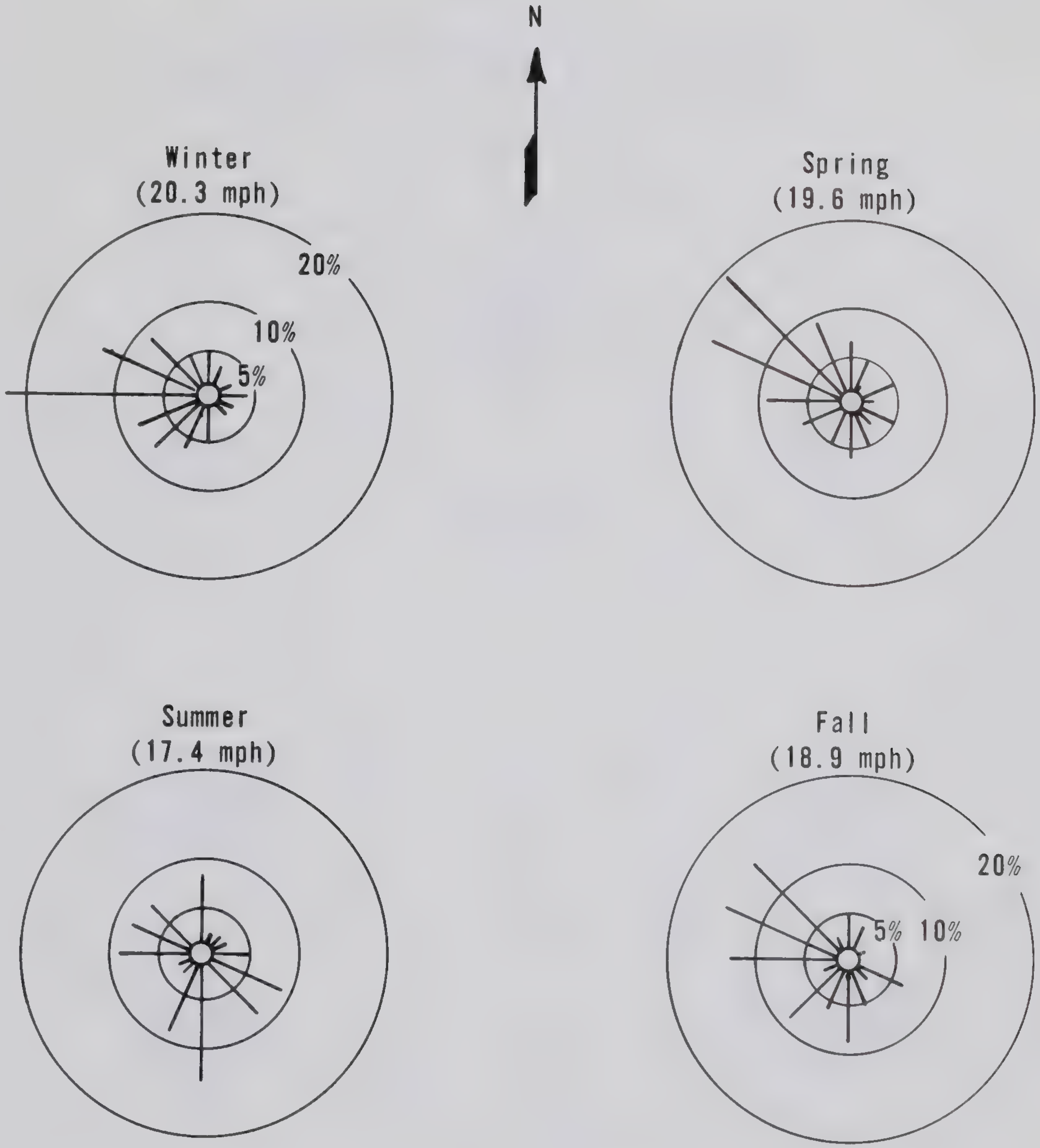
D. Fumigation

Fumigation is the term used to describe the situation in which the erosion of a ground based stable layer of air causes high ground level pollutant concentrations. When a plume from an elevated source such as a stack is injected into a stable layer appreciable dilution of the plume effluent will not occur for large distances downwind of the source. Surface heating may gradually erode the stable layer from the ground upward, replacing it with a neutral or unstable layer. If the neutral or unstable layer builds up to the plume elevation, plume effluent may be mixed rapidly to the surface thereby causing high



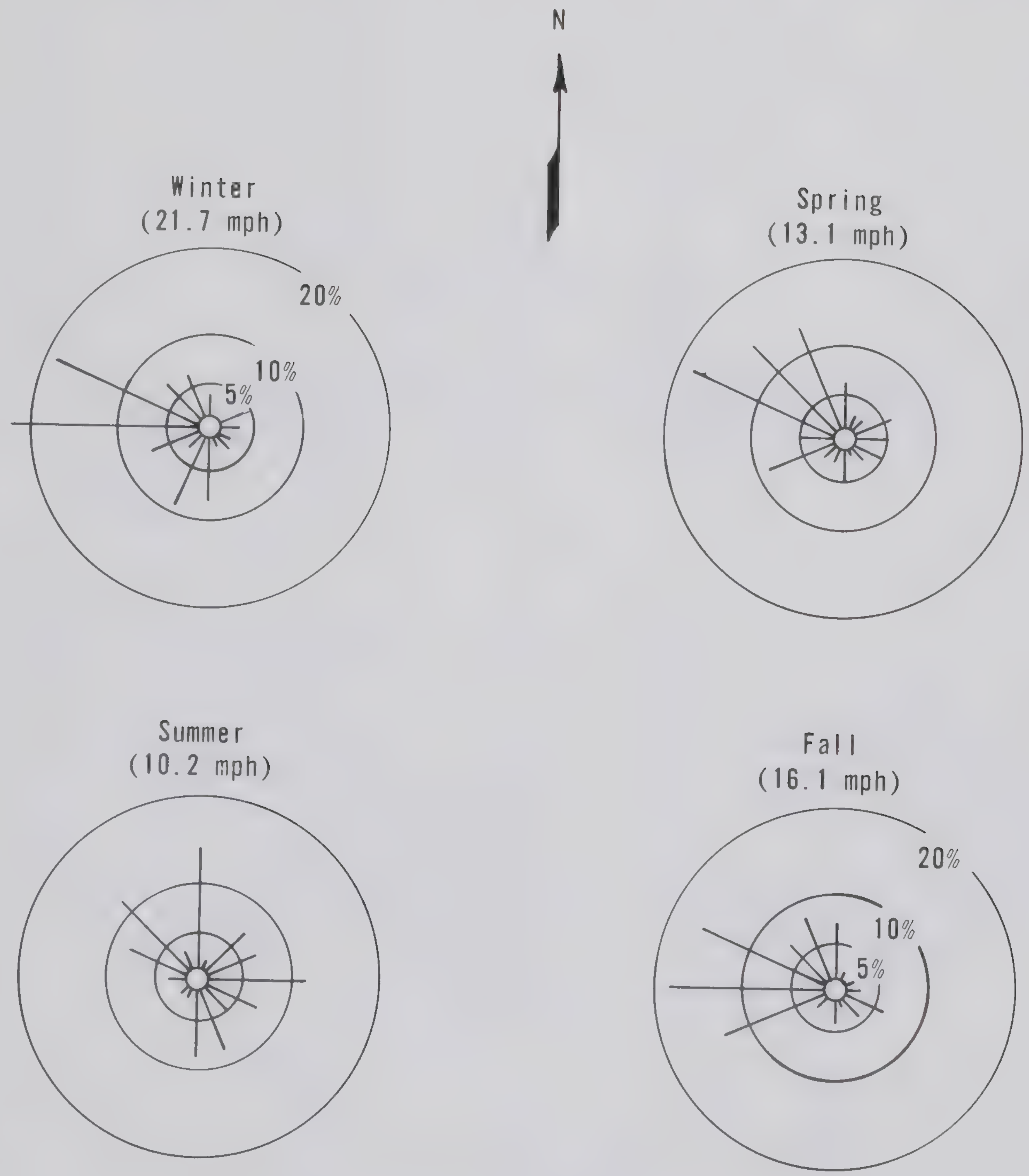
Seasonal and Annual Wind Roses at 307 ft. AGL.
(Numbers Indicate Mean Wind Speed)

FIGURE 10-1



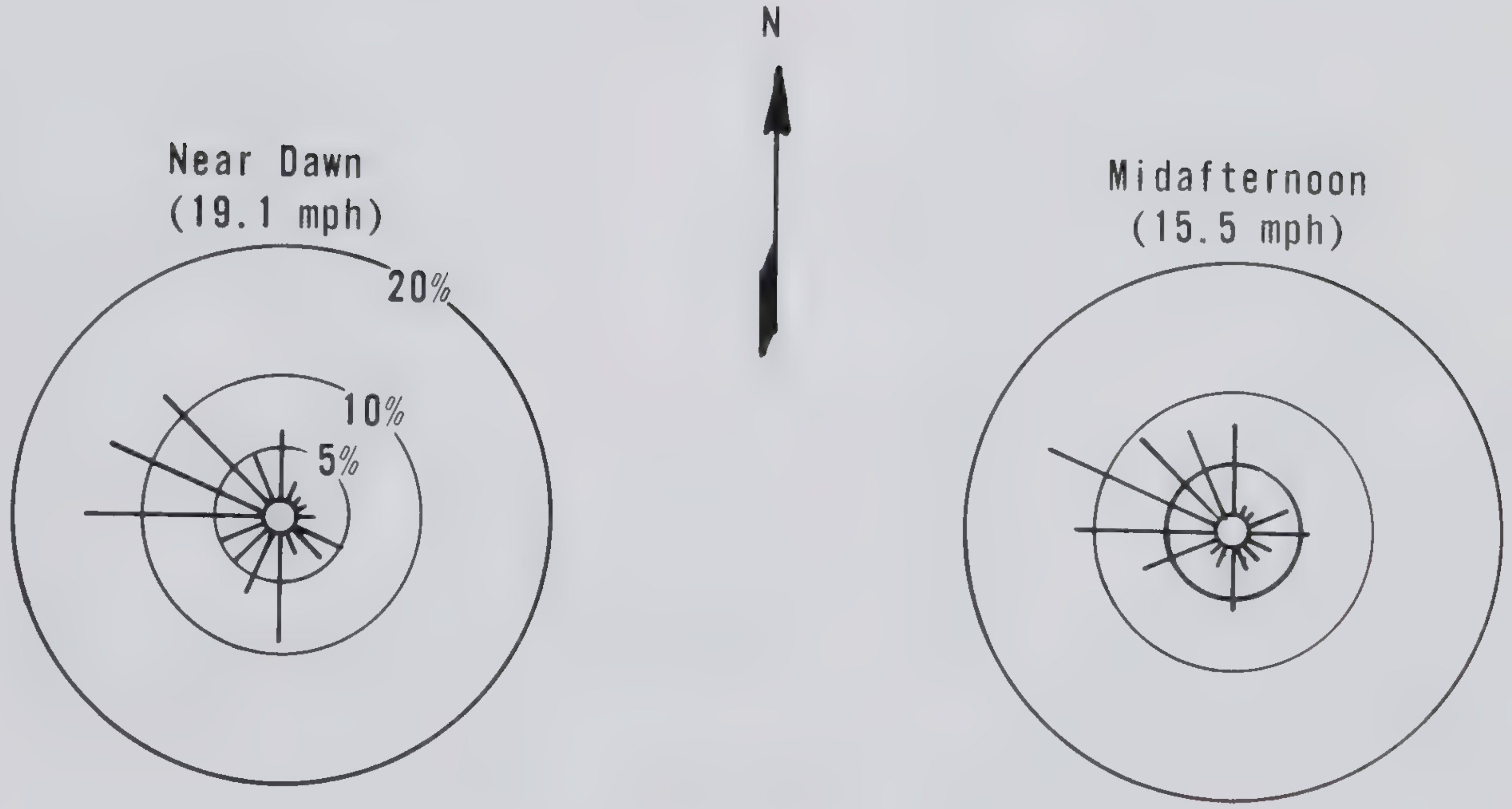
Seasonal Wind Roses at 1053 ft. AGL Based on All Near Dawn Pilot Balloon Observations. (Numbers Indicate Mean Wind Speed)

FIGURE 10-2



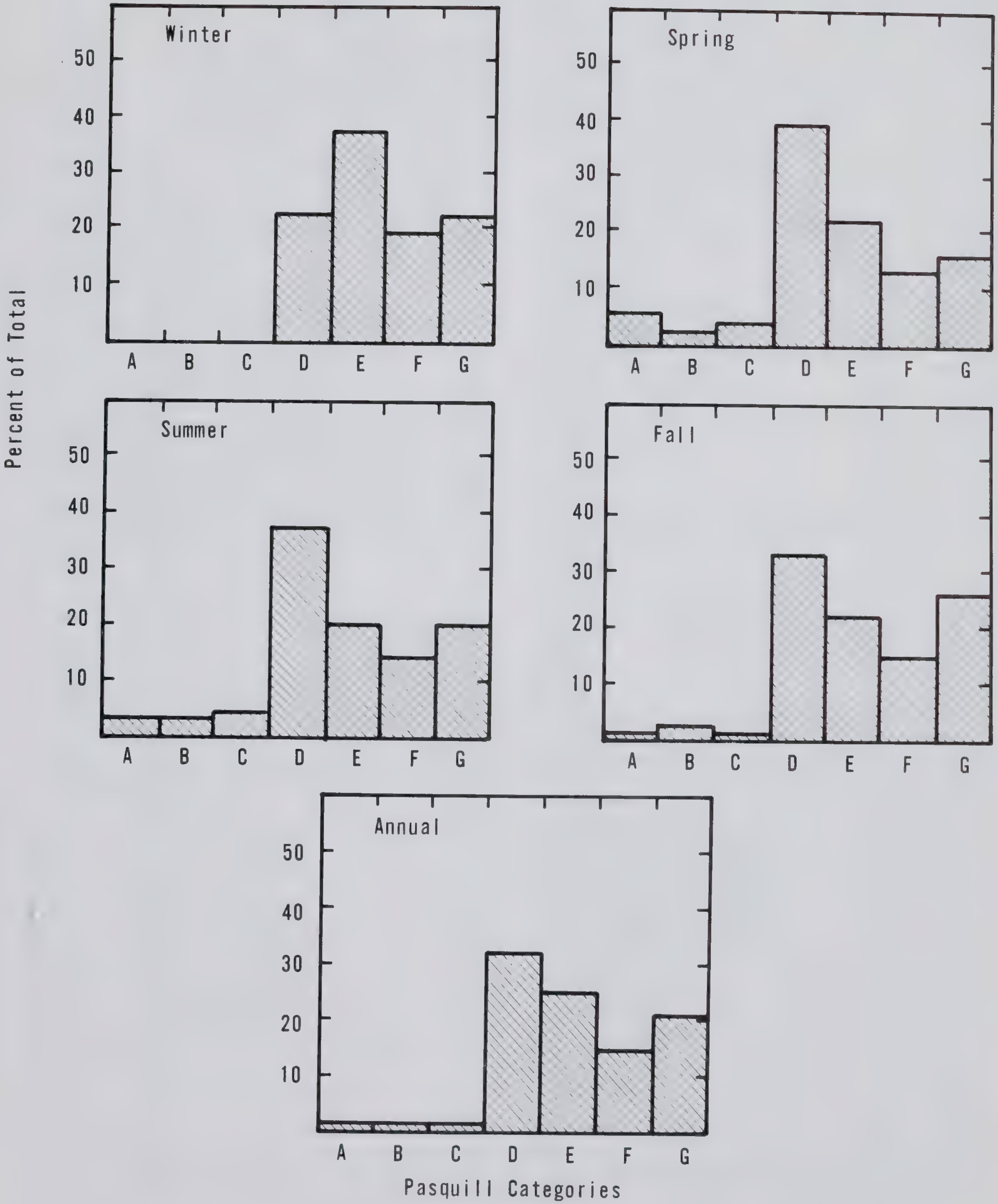
Seasonal Wind Roses at 1053 ft. AGL Based on All Midafternoon Pilot Balloon Observations. (Numbers Indicate Mean Wind Speed)

FIGURE 10-3



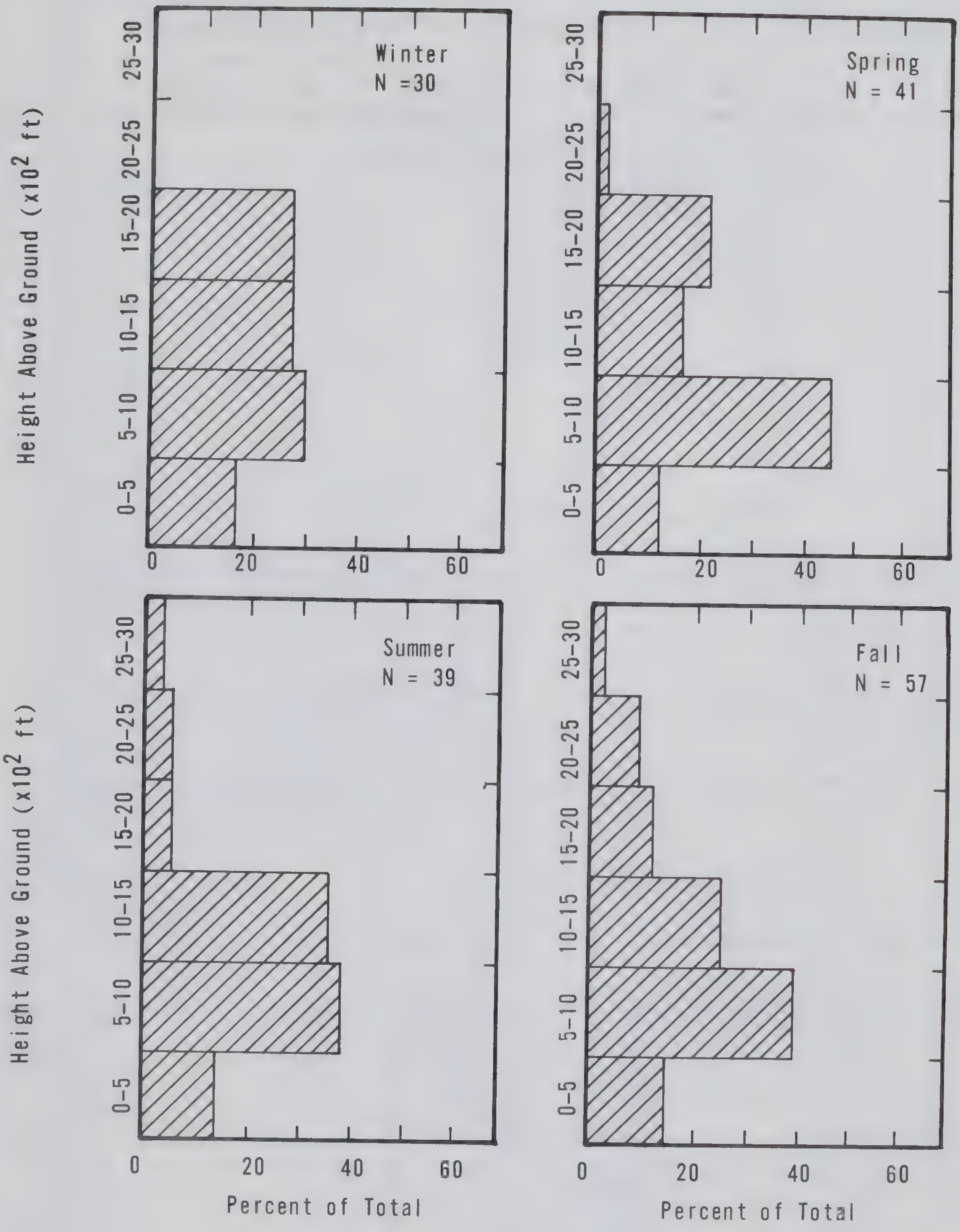
Annual Wind Roses at 1053 ft. AGL Based on All Pilot Balloon Observations. (Numbers Indicate Mean Wind Speed)

FIGURE 10-4



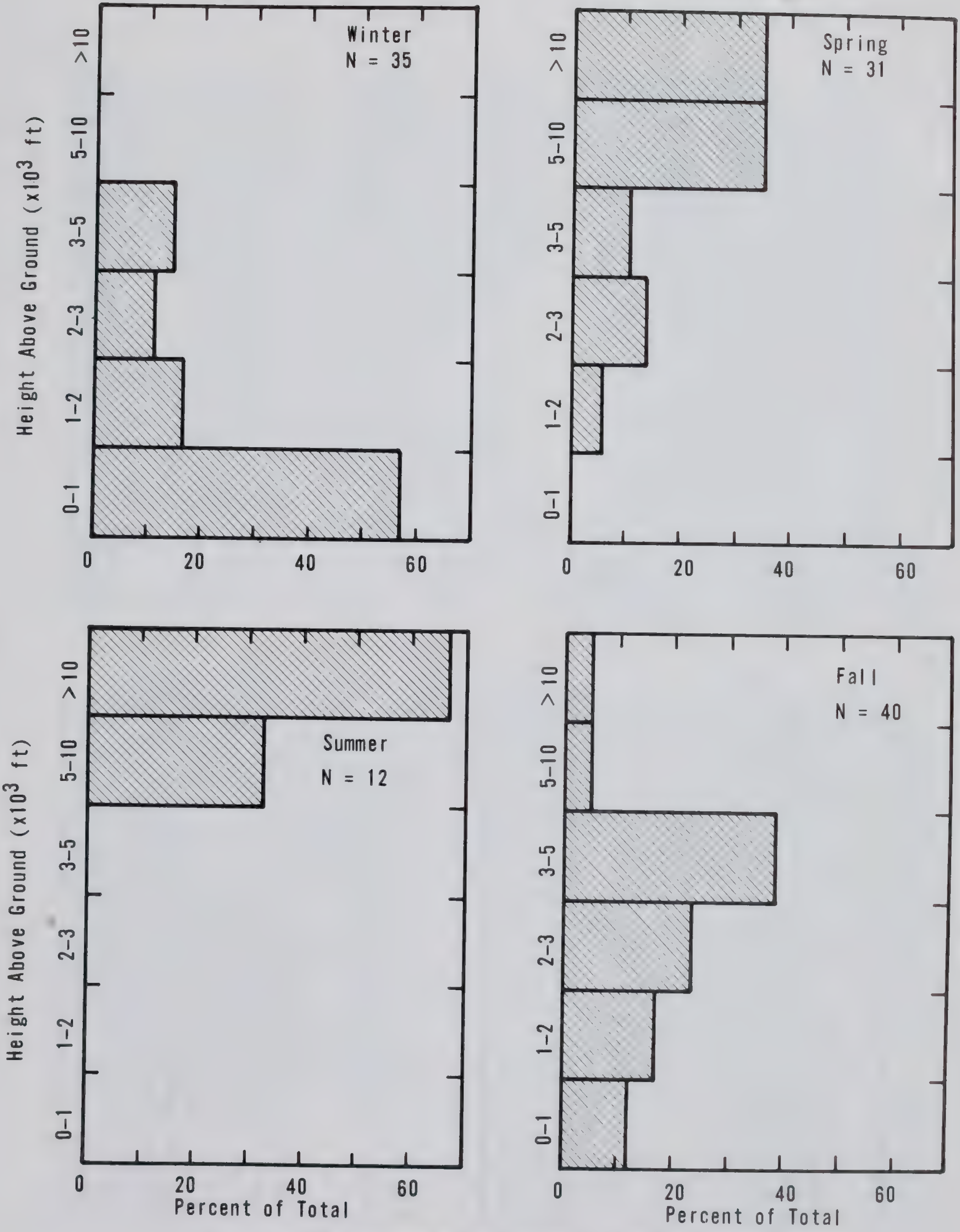
Seasonal and Annual Distribution of Pasquill Stability Categories

FIGURE 10–5



Frequency of Top Heights of Ground-Based Inversions and/or Isothermal Layers by Season. (Based on All Near Dawn Aircraft Soundings - Number Noted by "N")

FIGURE 10-6



Frequency of Maximum Mixing Depths by Season. (Based on all Midafternoon Aircraft Soundings - Number Noted by "N")

FIGURE 10-7

ground level concentrations for some time period. (Super et al. 1973).

Because ground based stable layers were found during almost all near dawn temperature soundings at Colstrip, the potential for fumigation would appear to be high. Maximum concentrations due to fumigation would be expected if the wind direction remained constant prior to and during the fumigation period. Westinghouse (1973) analyzed the year of hourly meteorological data taken at Colstrip to identify those cases when the atmospheric stability changed from stable (Pasquill classes E & F) to neutral (class D) or unstable (classes A, B, C) from one hourly period to the next, and when the 307 foot (94m) AGL wind direction remained in the same 22.5 degree sector during the last stable hour and at least the first following neutral or unstable hour. Based on these criteria 132 potential fumigation cases were detected.

Super et al. (1973) also examined the hourly data for number and frequency of possible fumigation situations. The above Westinghouse criteria were applied plus an additional wind speed check. The 750-foot AGL wind speed had to be equal to or less than five miles per hour for either the last stable hour, or first neutral or unstable hour, or both, before a potential fumigation period was identified. The wind speed criteria was applied to eliminate all cases which would not be expected to approach the Montana one hour SO_2 standard./9 Twenty-one periods met this criteria, eight of which were within four days of another period. Of these eight cases, only two periods in sequence within four days had the same wind direction; so that the same ground areas might be fumigated during the same four-day period.

It should be noted that the criteria used by Westinghouse and Super to identify potential fumigation cases were based on meteorological parameters. Whether or not the plume from Units 3 and 4 would actually be located within the stable layer prior to fumigation was not specifically considered. Using the data and methods described in Appendix A6 the effective plume rise for Units 3 and 4 was calculated for each morning for which a ground based inversion and/or isothermal layer was detected. The effective plume rise was predicted to be less than the top height of the stable layer for over 40% of the cases (74 out of 166 days).

To summarize, the above analyses indicated:

1) a ground based inversion and/or isothermal layer existed on 99% of the early mornings sampled (167 out of 169) (Super et al. 1973);

2) the Units 3 and 4 plume effective height was predicted to be within the inversion and/or isothermal layer on 44% of the sampled mornings on which such a layer was detected (74 out of 166);/10

3) Westinghouse's hourly stability class change and constant wind sector criteria indicated potential fumigation situations 132 times per year (36% of the days per year assuming each case identified occurred on a different day); and

4) the criteria used by Super et al. to identify only those cases which might cause state standards to be approached resulted in the identification of 21 cases, 18 of which occurred on

different days (5% of the days per year). Of these 21 cases, eight occurred within four days of another case, and two of the eight had the same wind direction with the same four day period.

Thus the potential may exist for fumigation by the plumes emitted by Colstrip Units 3 and 4 on about 40% of the days per year. The length of time that fumigation conditions can persist in the Great Plains is unknown (Northern Great Plains Resources Program 1974). However if that period approaches one hour the Montana state standards may be approached on about 5% of the days per year.

10.1.2. Air Quality

10.1.2.1. Parameters to be Assessed

The air quality analysis has been limited to certain pollutants which met one or more of the following criteria.

1) Existence of ambient standards for the pollutant

2) Indications from previous research that the pollutant could be a significant emission from coal-fired power plants

3) The probability that the pollutant may be easily detected by receptors.

Several other secondary parameters such as trace elements and particulate size were selected for background level determinations. The purpose of such monitoring was to provide documentation of the existing background levels so that future monitoring of ambient air can determine whether conditions have worsened.

Those parameters selected for analysis are listed in Table 10-2 together with other relevant information including type of instrumentation, location, number of monitors, parameter units and sampling periods.

10.1.2.2. Historical Data

Prior to the study, the Department of Health and Environmental Sciences, had sampled the southeastern Montana area for total suspended particulates, dustfall, fluorides in the air and vegetation, and the rate of SO_2 conversion to sulfate in the air. All of this material is presented in tabular form in Appendix A1.

10.1.2.3. On-Site Sample Collection

A. Sampling Sites

Monitoring sites in the Colstrip area were required to meet two criteria. First they were required to represent the background environment for the area, and secondly, they were to be properly positioned to detect any change in the ambient air after operations begin. Monitors were therefore located in a prevailing downwind direction from the proposed facilities.

Preliminary diffusion models were applied to

TABLE 10-2

Background Air Quality Parameters Monitored

Parameters	Units	Sampling Interval	Number of Monitors	Sites	Estimated Accuracy Limits	Analysis Method
Total Suspended Particulates (0.01 -100)	ug/m^3	24 hr.	2	B.N. & McRae	± 1 ug/m^3	Chem & Gravimetric
Settled Particulates (50)	tons/mi^2	monthly	4	B.N., McRae, Antenna Hill, Halfway	± 50%	Gravimetric
Particulate Size (.01 -50)	ug/m^3	72 hr.	2	B.N. & McRae	± 1 ug/m^3	Gravimetric
Trace Elements (Particulate .01 - 50)	ug/m^3	24 hr.	2	B.N. & McRae	± 10%	Chemical
Visibility (Particulates 0.01-2)	Miles	Continuous	2	B.N. & McRae	± 10% of scale	Light Scattering
Oxidized Sulfates (Gaseous Sulfur Compounds)	mg SO_3/ 100 cm^2/ day	Monthly	6	B.N., McRae, Sewage Lagoon, Colstrip West, Halfway, Antenna Hill		Turbidimetric
Sulfur Dioxide (SO_2)	ppm	Continuous	1	McRae	± .01 ppm	Coulometric
Sulfur Dioxide (SO_2)	ppm	72 hr.	2	B.N. & McRae		Modified West-Gaeke

TABLE 10-2 (cont.)

Parameters	Units	Sampling Interval	Number of Monitors	Sites	Estimated Accuracy Limits	Analysis Method
Nitrogen Oxide(NO)	ppm	Continuous	1	McRae	± .01 ppm	Chemiluminescence Photometric
Nitrogen Dioxide (NO_2)	ppm	Continuous	1	McRae	+ .01 ppm	Chemiluminescence Photometric
Oxides of Nitrogen (NO_x)	ppm	Continuous	1	McRae	± .01 ppm	Chemiluminescence Photometric
Nitrogen Dioxide (NO_2)	ppm	72 hr.	2	B.N. & McRae		Kristi
Ozone (O_3)	ppm	Continuous	1	McRae	± .001 ppm	Chemiluminescence
Carbon Monoxide (CO)	ppm	Continuous	1	McRae	± .3 ppm	Non-Dispersive Infrared
Fluorides(Gaseous F)	ug F/ cm^2/ 30 day	Monthly	2	McRae & B.N.	± 10%	Chemical
Fluorides(Gaseous F)	"	Monthly	4	McRae, B.N., Antenna Hill, Halfway	± 10%	Chemical
Ultra-violet Radiation (.259-.385)	mcal/ cm^2/ min	Continuous	1	McRae	± 2%	Photometric

TABLE 10-2 (cont)

Parameters	Units	Sampling Interval	Number of Monitors	Sites	Estimated Accuracy Limits	Analysis Method
Photosynthetic Active Radiation (.4-.7)	ueinsteins /m^2/sec.	Continuous	2	2-McRae	± 1%	Photochemical
Relative Humidity	Percent	Continuous	1	McRae	± 3%	Mechanical
Temperature	°F	Continuous	3	2-McRae, B.N.	± 3°F	Mechanical
Wind Direction	° from N	Continuous	2	B.N., McRae	± 1%	Mechanical
Wind Speed	Miles/hr	Continuous	2	B.N., McRae	± 2%	Mechanical

the proposed facilities with results indicating likely violation points. For instance, during short and infrequent periods the highest pollution concentrations may result at points close to the stack (about 4 km). For this reason a monitoring site approximately four kilometers (km) downwind to the southeast on an elevated ridge was chosen. This site is called the Burlington Northern (BN) site since land arrangements were required and negotiated with BN.

Preliminary modeling also indicated relatively high concentrations would result at distances between 15-35 km downwind from the proposed facilities. A site was selected on ranchland approximately 22 km southeast of the proposed plant site. The site is referred to as the McRae site since it is located on the McRae ranch.

Four other secondary sites were located at points surrounding the immediate Colstrip area to monitor ground level emissions from town and fugitive dust emissions from the plant. The secondary monitors were of an indicator nature and did not require instrument shelters or electrical facilities.

Figures 10-8 and 10-9 are photographs taken of the sites from specified aerial observation points. Table 10-3 provides supplementary information describing the physical characteristics of all sites.

A detailed discussion of the functions of major monitoring equipment and the methods of analysis employed by each is found in Appendix A2. The information is summarized in Table 10-4. Methods of maintaining the quality of the equipment and the accuracy of the samples are also discussed in Appendix A2.

B. Results of Sampling

Results of the ambient sampling by HES for 1973-74 are summarized in Tables 10-5 through 10-14 and Figures 10-10 through 10-12. Table 10-5 and Figures 10-10 and 10-11 show levels of total suspended particulates measured in the Colstrip area from mid-November 1973 through June 1974. Both sites demonstrate very similar results with levels well below the Montana and federal air quality standards. Table 10-6 displays settleable particulates over the same period as above. Values are quite low with the sites closest to Colstrip showing the highest values.

Comparisons of particulate sizing data (Table 10-7 and Figure 10-12) for two sites near Colstrip demonstrate that the site closer to the town (BN Site) has more large particles (particles greater than 1.0 micron) and a larger percentage of the mass therefore is made up of these larger particles. The McRae site (farthest from town) has a larger percentage of the mass made up of small particles (less than 1.0 micron). Particulate loading at the BN site is also greater than the McRae site.

Results of trace element analysis (performed on membrane filters) are shown in Table 10-8. The highest values of total mass per unit volume of air were detected for iron and calcium. For most of the elements listed in Table 10-8, the site closer to Colstrip (BN site) had readings higher than or equal to those from the McRae site.

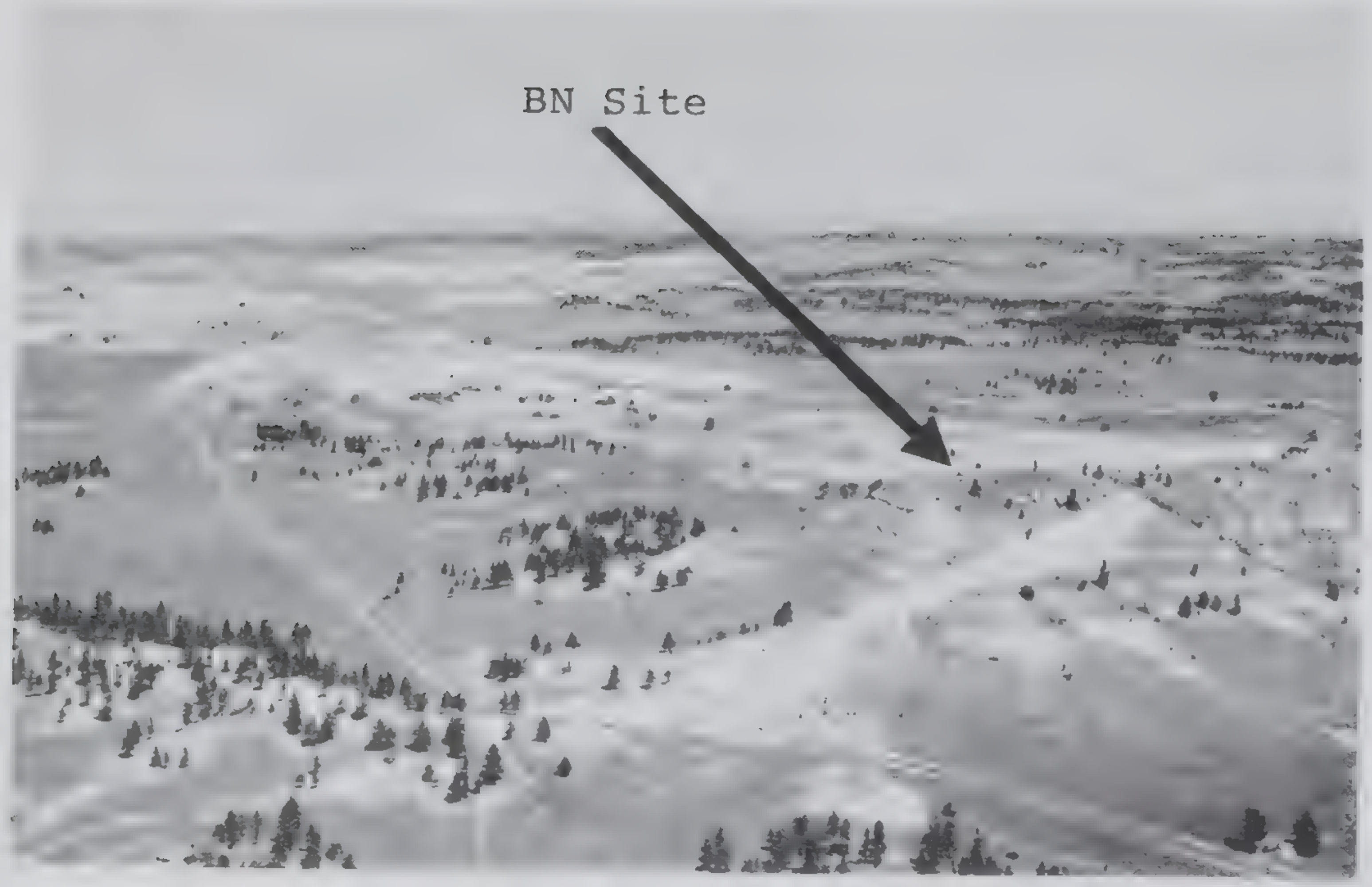


Figure 10-8

Aerial view of the Burlington Northern site from the south-southeast.

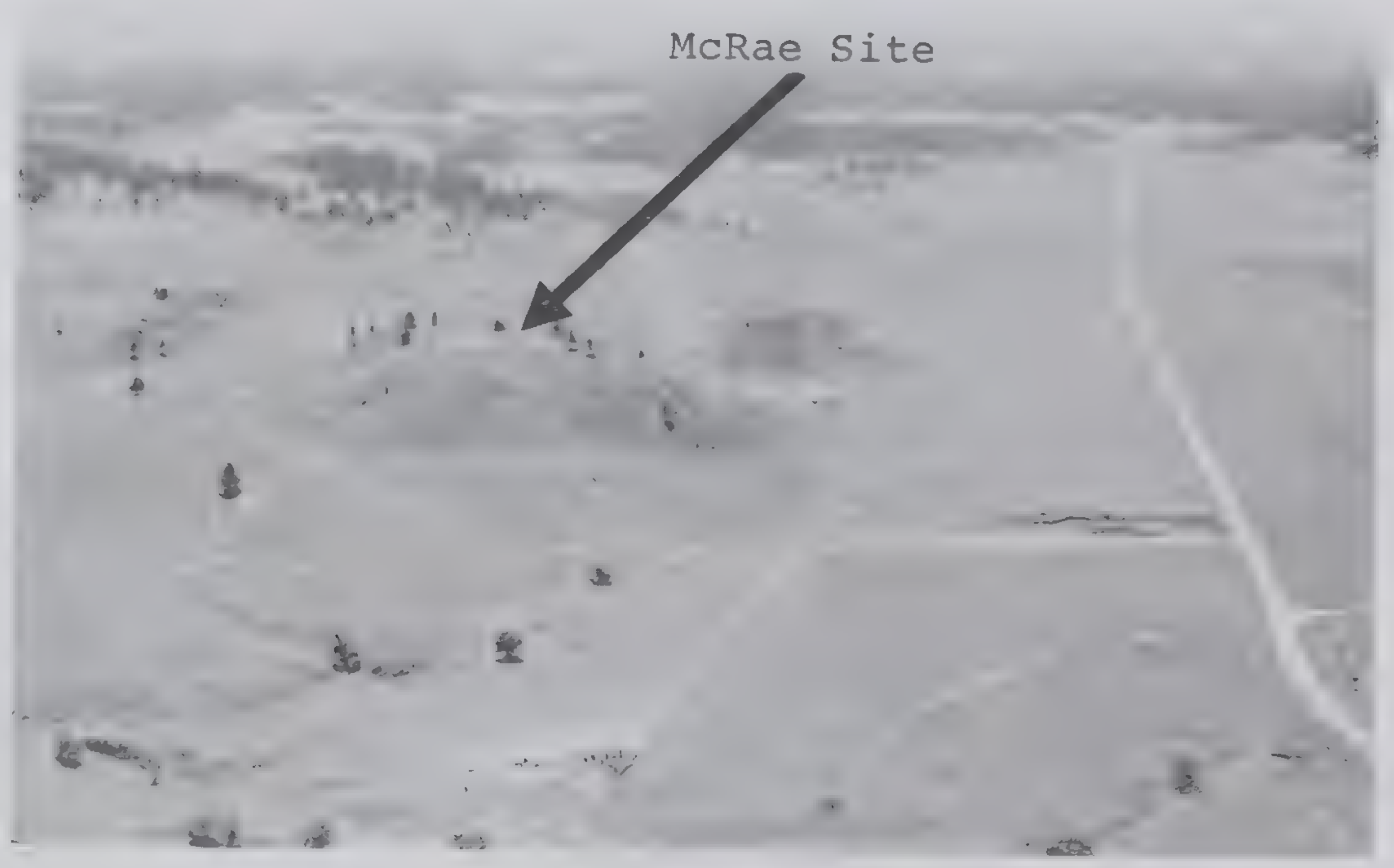


Figure 10-9

Aerial view of the McRae site from the north-northwest.

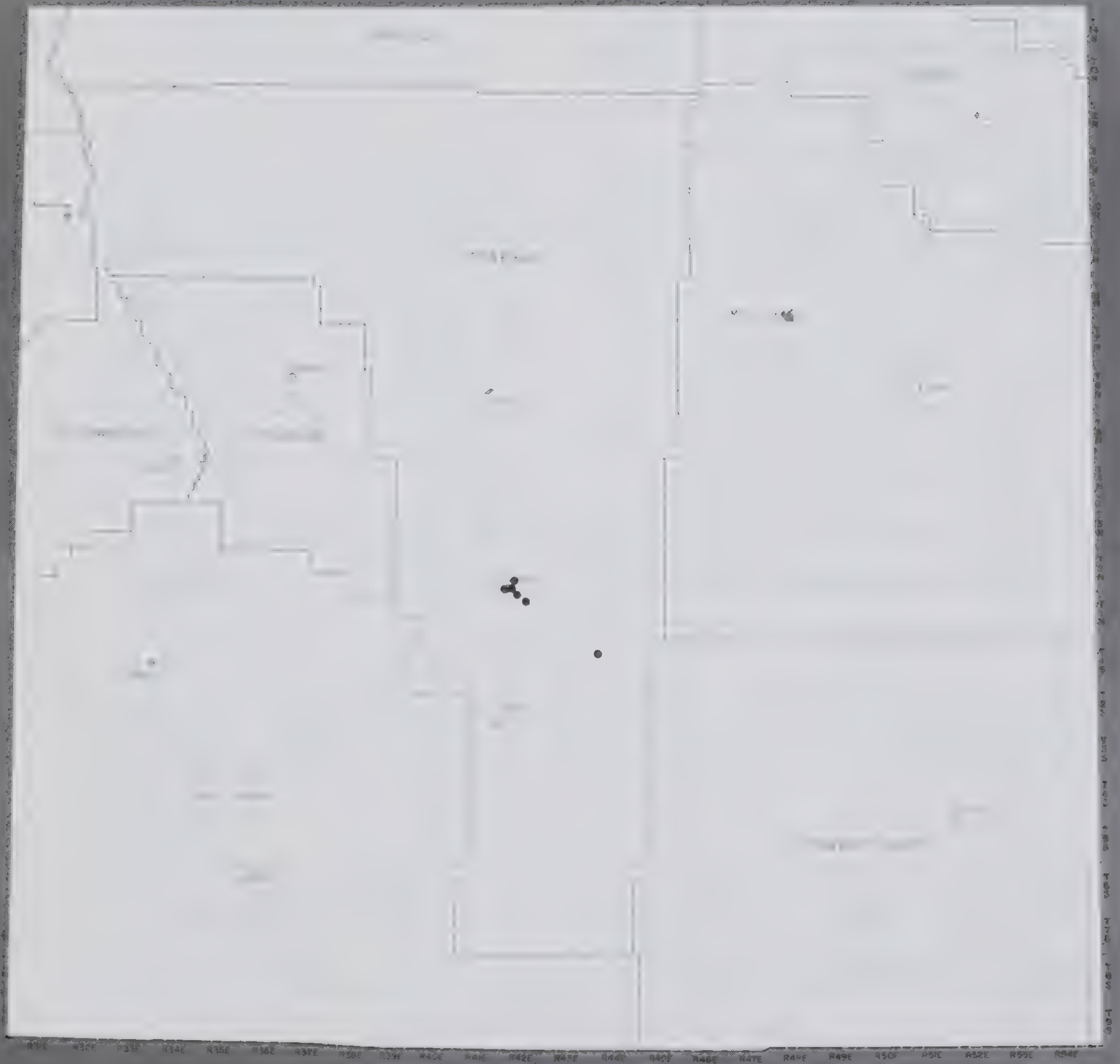
TABLE 10-3/1

MONITORING SITES

Site	Elevation Feet MSL	Direction From Plant	Distance From Plant	Number of Monitors
BN	3570	Southeast	4 Km	13
McRae	3215	Southeast	22 Km	24
Halfway	3390	Southeast	1.95 Km	3
Antenna Hill	3450	North-Northeast	1.20 Km	3
Colstrip	3320	West-Southwest	1.25 Km	1
Sewage Lagoon	3210	Northwest	1.05 Km	1

/1 These sites are shown on the accompanying air quality sampling site map.

AIR MONITORING SITES



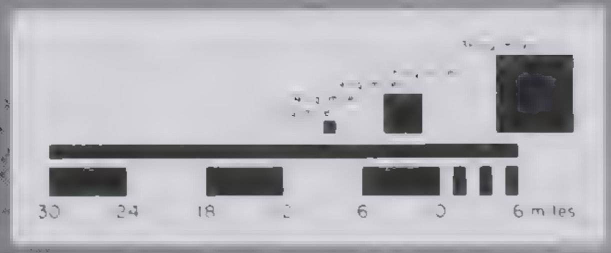


TABLE 10-4

Summary of Monitoring Methods and Equipment

Parameter	Site	Sampler Type	Instrumentation Method	Units	Length of Sampling Period	Detection Limit
Sulfur Dioxide	McRae	Bubbler	West Gaeke Bubbler	ppm	72 hour	.003 ppm
Sulfur Dioxide	McRae	Continuous	Coulometric	ppm	72 hour	.003 ppm
Sulfur Dioxide	McRae	Continuous	Coulometric	ppm	1 hour	.01 ppm
Sulfation	McRae	PbO_2 plates	Lead Peroxide	ppm	1 hour	.05 ug/ cm^2/day
Sulfation	B.N.	PbO_2 plates	Lead Peroxide	ppm	1 hour	"
Sulfation	Halfway	PbO_2 plates	Lead Peroxide	ppm	1 hour	"
Sulfation	Antenna Hill	PbO_2 plates	Lead Peroxide	ppm	1 month	"
Sulfation	Colstrip West	PbO_2 plates	Lead Peroxide	ppm	1 month	"
Sulfation	Sewage Lagoon	PbO_2 plates	Lead Peroxide	ppm	1 month	"
Nitrogen Dioxide	B.N.	Bubbler	Kristi Bubbler	ppm	72 hour	.001 ppm
Nitrogen Dioxide	McRae	Bubbler	Kristi Bubbler	ppm	72 hour	.001 ppm
Oxides of Nitrogen	McRae	Continuous	Chemiluminescence	ppm	1 hour	0.1 ppm
Nitrogen Dioxide	McRae	Continuous	Chemiluminescence	ppm	1 hour	0.1 ppm
Nitrogen Oxide	McRae	Continuous	Chemiluminescence	ppm	1 hour	0.1 ppm

TABLE 10-4 (cont.)

Parameter	Site	Sampler Type	Instrumentation Method	Units	Length of Sampling Period	Detection Limit
Ozone	McRae	Continuous	Chemiluminescence	ppm	1 hour	0.001 ppm
Carbon Monoxide	McRae	Continuous	Infra-red	ppm	1 hour	0.3 ppm
Fluoride	McRae	$Ca(COOH)_2$	Calcium Formate	$\mu g/cm^2$/ 30 days	1 month	10%
Fluoride	B.N.	$Ca(COOH)_2$	Calcium Formate	"	1 month	10%
Fluoride	Halfway	$Ca(COOH)_2$	Calcium Formate	"	1 month	10%
Fluoride	Antenna Hill	$Ca(COOH)_2$ Papers	Calcium Formate	"	1 month	10%
Fluoride	McRae	NaCOOH Plates	Sodium Formate	"	1 month	10%
Fluoride	B.N.	NaCOOH Plates	Sodium Formate	"	1 month	10%
Trace Elements	McRae	Membrane	Membrane Sampler	"	24 hour	10%
Trace Elements	B.N.	Membrane	Membrane Sampler	"	24 hour	10%
Suspended Part.	McRae	Hi-vol	High-Volume Sampler	ug/m^3	24 hour	.5 ug/m^3
Suspended Part.	B.N.	Hi-vol	High-Volume Sampler	ug/m^3	24 hour	.5 ug/m^3
Suspended Part.	Sidney	Hi-vol	High-Volume Sampler	ug/m^3	24 hour	.5 ug/m^3
Suspended Part.	Miles City	Hi-vol	High -Volume Sampler	ug/m^3	24 hour	.5 ug/m^3

TABLE 10-4 (cont.)

Parameter	Site	Sampler Type	Instrumentation Method	Units	Length of Sampling Period	Detection Limit
Suspended Part. Sizing	B.N.	Cascade	Cascade Impactor	ug/m^3	24 hour	.5ug/m^3
Sus. Part Sizing	McRae	Cascade	Cascade Impactor	ug/m^3	48 hour	.5 ug/m^3
Settled Part.	McRae	Dustfall	Dustfall	ug/m^3	48 hour	1 ton/mi-MU
Settled Part.	B.N.	Dustfall	Dustfall	tons/mi^2 month	1 month	"
Settled Part.	Halfway	Dustfall	Dustfall	"	1 month	"
Settled Part.	Antenna Hill	Dustfall	Dustfall	"	1 month	"
UV Radiation	McRae	Continuous	Photometer	mcal/cm^3 min	1 hour	2 mcal/cm^2-mile
Photosynthetic Active Radiation	McRae	Continuous	Quantum Sensor	Microein-steings/M^2/sec	1 hour	100 ceinsteing m^2/cm
Visibility	McRae	Continuous	Nephelometer	Miles	1 hour	10%
Visibility	B.N.	Continuous	Nephelometer	Miles	1 hour	10%
Wind Direction	McRae	Continuous	Mechanical	degrees from N. miles/hr	1 hour	10 degrees 2 mph
Wind Speed	McRae	Continuous	Mechanical	degrees F	1 hour	2^{o}F

TABLE 10-4 (cont.)

Parameter	Site	Sampler Type	Instrumentation Method	Units	Length of Sampling Period	Detection
Temperature	McRae	Continuous	Bimetal	degrees N	1 hour	10 degrees
Wind Direction	B.N.	Continuous	Mechanical	degrees N	1 hour	10 degrees
Wind Speed	B.N.	Continuous	Mechanical	miles/hr	1 hour	2 mph
Temperature	B.N.	Continuous	Bimetal	degrees F	1 hour	2^oF
Relative Humidity	McRae	Continuous	Hair Hygrometer	percent	2 hour	3%
Temperature	McRae	Continuous	Bimetal	degrees F	2 hour	2^oF

TABLE 10-5

Total Suspended Particulate Data*
Miles City Air Quality Control Region
1973-1974
(measured in ug/m^3)

Station	Minimum	Frequency Distribution (% of values equal to or less than stated one)							Maximum	Arith. Mean	Arith. Std. Dev.	Geo. Mean	Geo. Std. Dev.	Total No. Obs.
		10%	30%	50%	70%	90%	95%	98%						
BN Site Rosebud Co. 1360027	2	4	7	9	12	26	33	39	54	13	10	10	2	75
McRae Site Rosebud Co. 1360028	1	4	6	8	11	25	34	46	60	12	11	9	2	71

TABLE 10-5 (cont.)

Number of Samples Reported Per Month*											
January	February	March	April	May	June	July	August	September	October	November	December
10	10	10	10	10	10	--	--	--	--	5	10
10	9	8	10	10	10	--	--	--	--	5	9

* These data were collected to establish a baseline. The values cited are not unusual and no state or federal standard was approached.

* Samplers operated from Nov. 73 through June 74 at the time of this EIS.

TABLE 10-6

Settleable Particulates (Dustfall Jar)*
Values in Tons per Square Mile
Operational Period: Nov. 73 - May 74

Sampler Location	Average Value	Max. Value	No. of Samples
Rosebud County BN Site 1360027	6.9	11.4	3
Rosebud County McRae Site 1360028	3.4	7.7	5
Rosebud County Halfway Site 1360029	5.0	6.9	3
Rosebud County Antenna Hill 1360030	5.1	11.7	5

TABLE 10-7

Arithmetic Average Particulate Sizing Data*
Cascade Impactor (Run 48 Hours)
Period: December, 1973 - April, 1974

Particle Size (Microns)	BN Site	McRae Site
7.0 and	3.42 (27.3)*	1.95 (20.8)*
3.3 - 7.0	2.19 (17.5)	1.32 (14.1)
2.0 - 3.3	1.22 (09.7)	0.84 (09.0)
1.1 - 2.0	0.85 (06.7)	0.54 (05.8)
Submicron	4.86 (38.8)	4.71 (50.3)
Total	12.54	9.86
No. of samples	41	41

* Values in parentheses are average percentages of the total particulate load.

No state or federal standard would be approached by the values shown.

TABLE 10-8

Membrane Filters (Trace Element Analysis)*
Average Values in $\mu g/m^3$
Operational Period: Nov. 1973 - June 1974

Element	BN Site	McRae Site
Antimony	0.002	0.002
Tin	0.020	0.020
Vanadium	0.005	0.005
Beryllium	0.0001	0.0001
Chromium	0.001	0.001
Lead	0.0156	0.127
Cadmium	0.00004	0.00006
Strontium	0.00045	0.00033
Silver	0.001	0.001
Manganese	0.0042	0.0039
Zinc	0.0402	0.0493
Copper	0.008	0.008
Iron	0.151	0.123

TABLE 10-8 (cont.)

Element	BN Site	McRae Site
Mercury	0.0002	0.0002
Calcium	0.212	0.115
Magnesium	0.047	0.047
Lithium	None Detected	None Detected
Sodium	0.064	0.047
Potassium	0.049	0.040
Selenium	0.001	0.001
Average No. Samples	41	41

* These data were collected to establish a baseline and are not believed to be particularly high or low. There are no other data for comparison.

TABLE 10-9

Sulfation Rate (Lead Plate)**
Values in milligrams SO_3 per 100 square centimeters per day
Operational Period: Nov. 73 - June 74

Sampler Location	Aver. Value	Max. Value	No. of Samples
Rosebud County BN Site 1360027	0.046	0.090	5
Rosebud County McRae Site 1360028	0.006	0.030	8
Rosebud County Halfway Site 1360029	0.033	0.070	6
Rosebud County Antenna Hill 1360030	0.019	0.060	8
Rosebud County Sewage Lagoon 1360031	0.114	0.350	8
Rosebud County Colstrip West 1360032	0.036	0.070	7

** No state or federal pollution standard would be approved by the values shown.

TABLE 10-10

Sulfur Dioxide (Gas Bubbler)**
Values in parts per million SO_2
Operational Period: Nov. 73 - June 74

	Rosebud Co. BN Site 1360027	Rosebud Co. McRae Site 1360028
Geometric Mean	0.0000	0.0000
Geometric Std. Dev.	0.0002	0.0002
Arithmetic Mean	0.0001	0.0001
Max. 24-hour value	0.0010	0.0010
No. Samples Taken*	192	204

* Samplers were normally run for 72 hours which in this table constitutes three samples (24 hours per sample)

** No state or federal pollution standard would be approached by the values shown.

TABLE 10-11

Nitrogen Dioxide (Gas Bubbler)**
Values in parts per million NO_2
Operational Period: Nov. 73 - June 74

	Rosebud Co. BN Site 1360027	Rosebud Co. McRae Site 1360028
Geometric Mean	0.0012	0.0012
Geometric Std. Dev.	0.0002	0.0002
Arithmetic Mean	0.0014	0.0015
Maximum 24-hr. value	0.0030	0.0050
No. Samples Taken*	192	204

* Samplers were normally run for 72 hours which in this table constitutes three samplers (24 hours per sample)

** No state or federal pollution standard would be approached by the values shown.

TABLE 10-12

Continuous Monitor Data **
McRae Site
(ppm)

Pollutant	Arith. Aver.	Max. 1-hr Value	No. Days Data	No. Samples Taken	Operational Period
Sulfur Dioxide	0.00	0.00	222	4684	11/73-6/74
Carbon Monoxide	0.00	0.00	166	3218	11/73-6/74
Ozone	0.03	0.08	184	3820	12/73-6/74
Nitric Oxide	0.00	0.00	159	3649	12/73-6/74
Nitrogen Dioxide	0.00	0.00	171	3911	12/73-6/74
Oxides of Nitrogen	0.00	0.00	159	3645	12/73-6/74

** No state or federal pollution standard would be approached by the values shown.

TABLE 10-13

Fluorides in the Air (Na Formate Plates)*
Values in micrograms fluoride per square centimeter per 30 days
Operational Period: Nov. 1973 - June 1974

Sampler Location	Average Value	Max. Value	No. of Samples
Rosebud Co. BN Site 1360027	0.03	0.07	6
Rosebud Co. McRae Site 1360028	0.01	0.05	8
Rosebud Co. Halfway Site 1360029	0.03	0.05	5
Rosebud Co. Antenna Hill 1360030	0.01	0.05	8

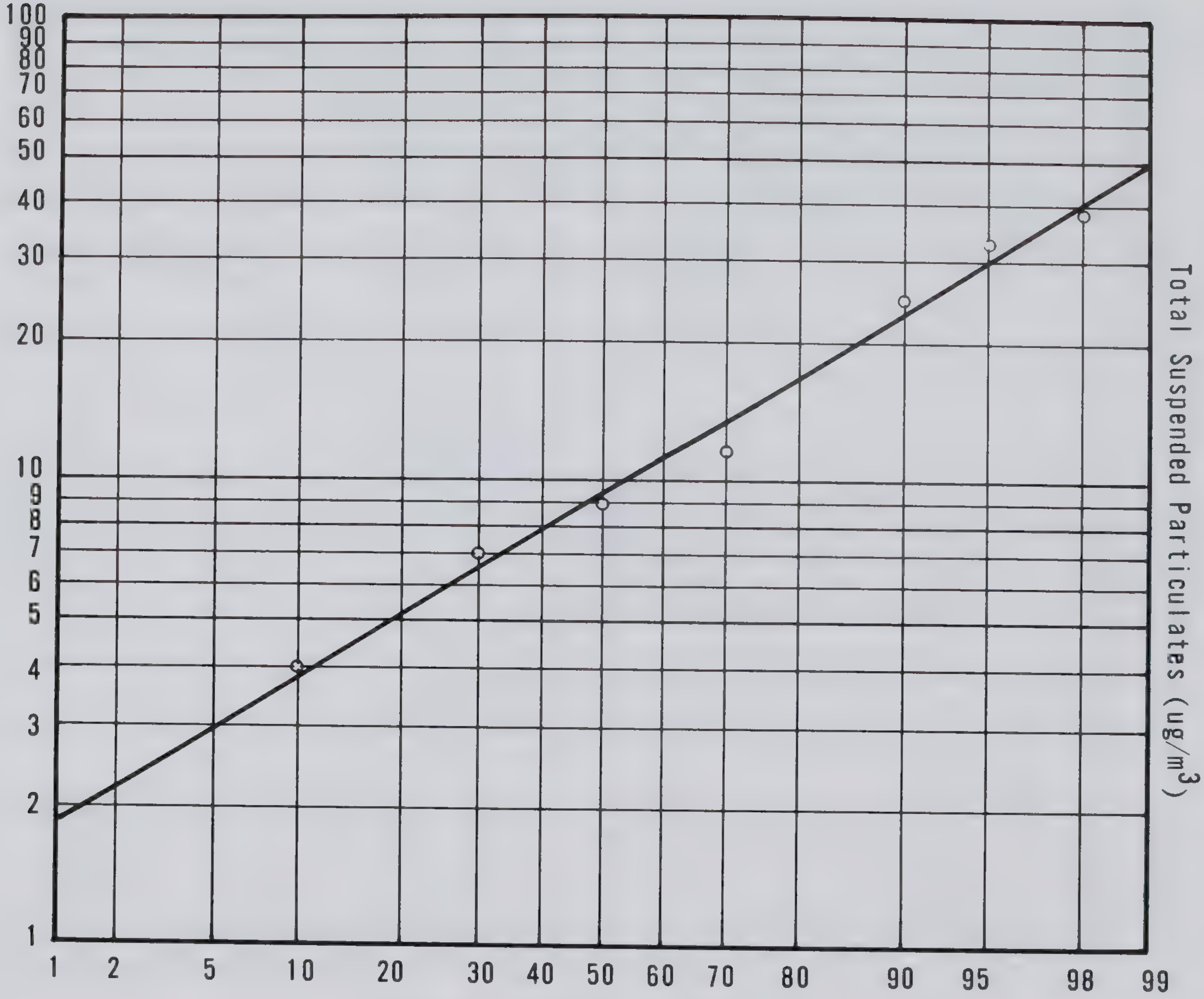
* No state or federal standards would be approached by the values shown.

TABLE 10-14

Fluorides in the Air (Ca Formate Papers)*
Values in micrograms fluoride per square centimeter per 30 days
Operational Period: Nov. 1973 - June 1974

Sampler Location	Average Value	Max. Value	No. of Samples
Rosebud Co. BN Site 1360027	0.03	0.23	7
Rosebud Co. McRae Site 1360028	0.02	0.09	7

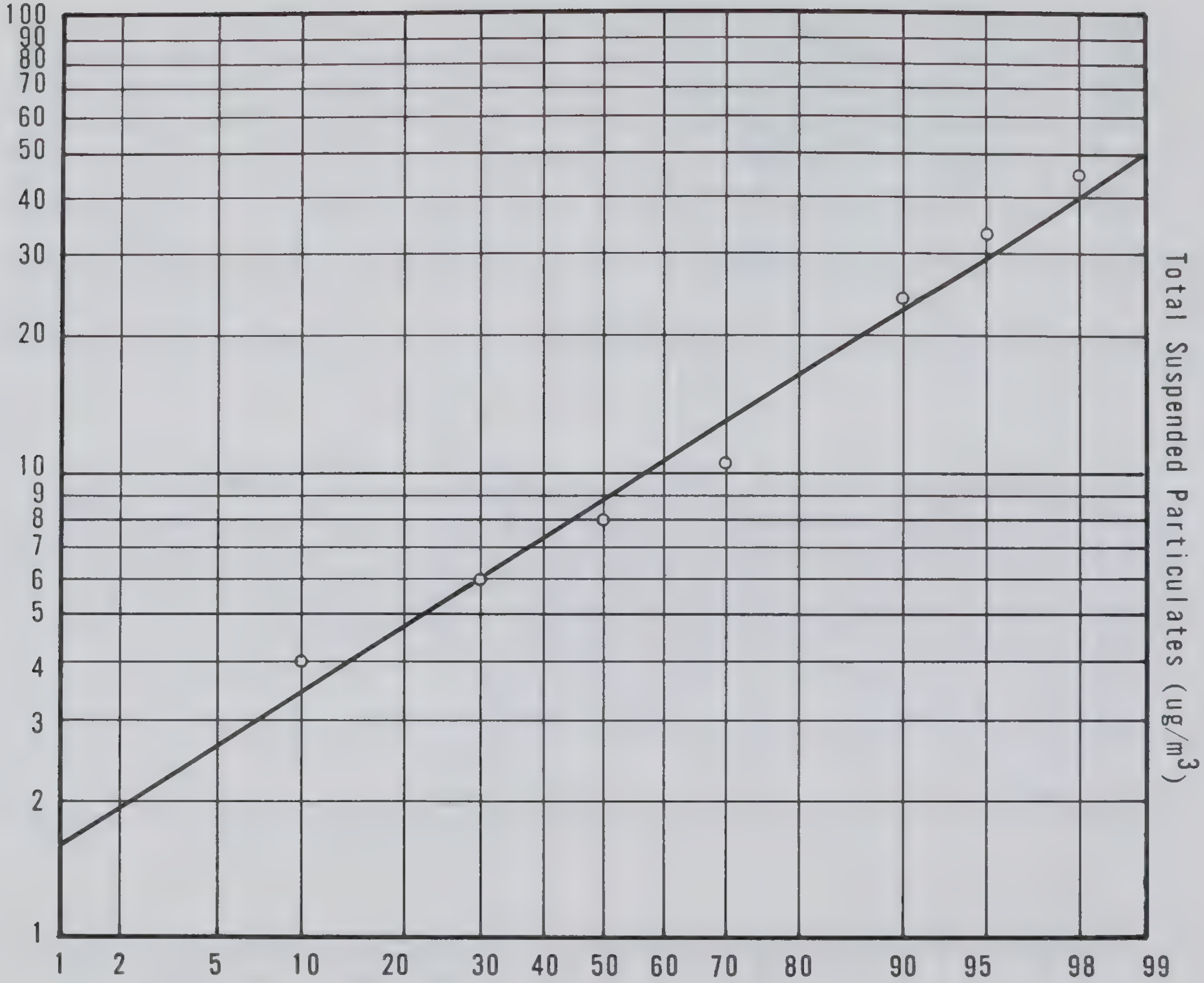
* No state or federal standards would be approached by the values shown.



Cumulative Probability (%)

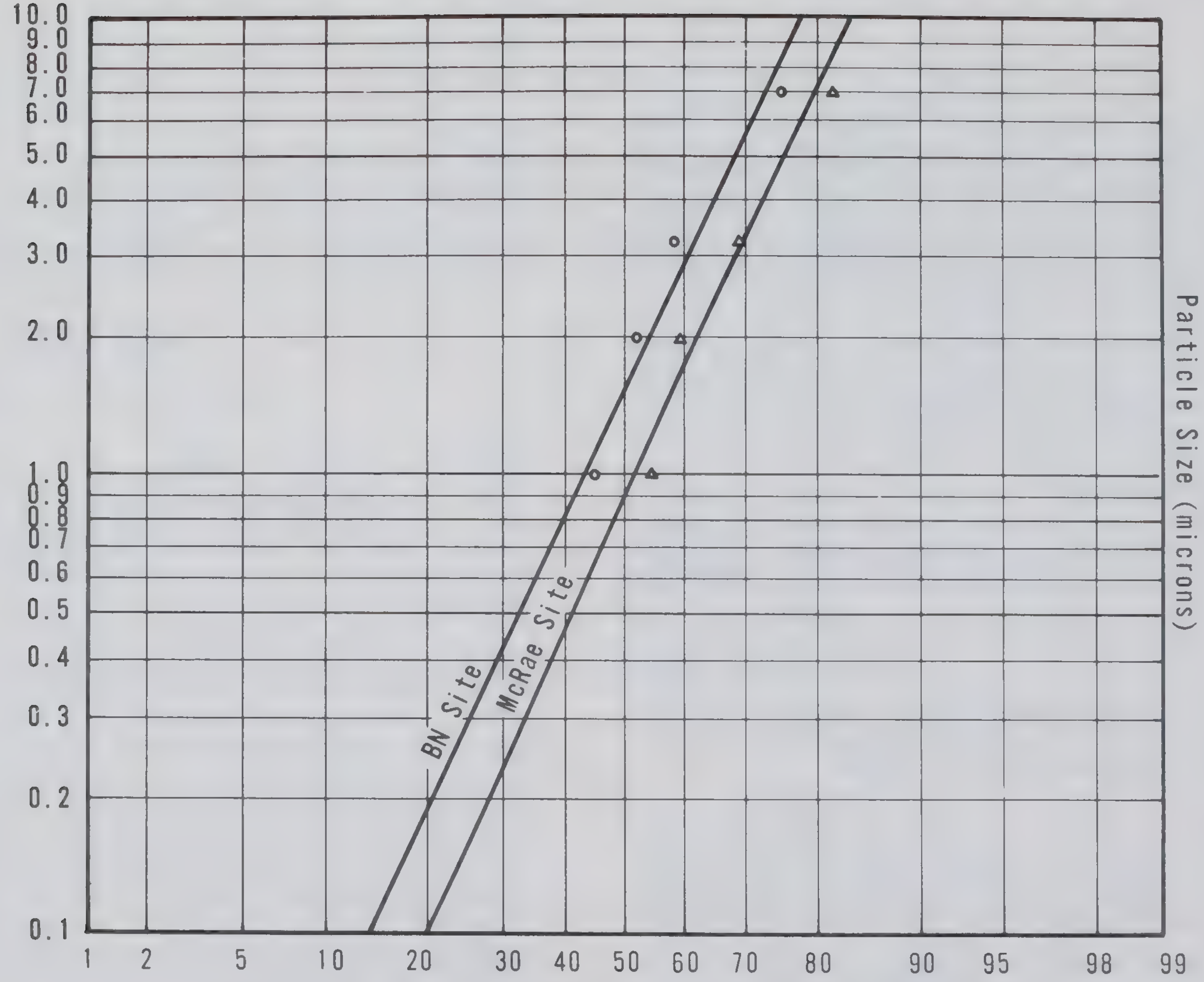
Total Suspended Particulate Frequency Distribution
Operational Period: Nov. 73 - June 74
BN Site

FIGURE 10-10



Total Suspended Particulate Frequency Distribution
Operational Period: Nov. 73 – June 74
McRae Site

FIGURE 10-11



Cumulative Percent of Mass less than Particle Size

Particle Size Frequency Distribution
Operational Period: Dec. 73 – April 74

FIGURE 10–12

Sulfation rates (Table 10-9) measured from November 1973 - June 1974, were well below the standards with only one site recording values in excess of 0.10 milligrams per 100 square centimeters per day. This site was near the sewage lagoon at Colstrip where higher readings would be expected because of the gases from the lagoon.

Sulfur dioxide and nitrogen dioxide as measured by two gas bubblers are summarized in Tables 10-10 and 10-11. Continuous analyzer data is shown in Table 10-12.

Sulfur dioxide concentrations were measured by two gas bubblers and a continuous analyzer. Only very low background values were detected. The maximum concentration measured was 0.001 ppm for a 24-hour average by gas bubblers at both sites. Similar results were obtained for nitrogen dioxide, carbon monoxide, and oxides of nitrogen. Ozone levels were higher than expected with the average value of 0.03 ppm. The maximum one-hour concentration measured was 0.08 ppm.

Fluoride levels in the air were also very low (Tables 10-13 and 10-14). Average values were below 0.05 micrograms with the highest monthly reading at the BN site of 0.23 micrograms.

Specific comments concerning the data are included with the tables as follows. For purposes of comparison and information, the existing state and federal standards for various pollutants are provided in Appendix A3.

10.1.3. Hydrology

In order to assess possible impacts of Units 3 and 4 on study area water systems, an inventory was conducted of water quantity and quality for both surface and ground water systems. Precipitation chemical content was also analyzed.

10.1.3.1. Surface Water

A. Definition of the Study Area

Possible water quality effects of developments around Colstrip were considered on three levels--local, regional, and basin-wide. Attention was specifically directed towards Units 3 and 4; however, additive effects of Units 1 and 2, currently being constructed, were also considered. At the local study level, which includes mining areas near Colstrip and the area closely surrounding the proposed generation plants, water quality itself was the main consideration. Stack emissions were the primary water quality concern on a regional level; because of the possibility of deposition of airborne pollutants onto the ground surface and into surface waters, potential influences were estimated to extend approximately 100 km (62 miles) beyond Colstrip, primarily southeast due to prevailing winds. On a basinwide level, potential dewatering effects of pumping from the Yellowstone River were the major consideration.

In attempting to establish appropriate sampling sites in the regional study area, an ellipse was constructed with Colstrip at one foci. These sites are shown on the accompanying map of the study area entitled "Surface Water". The major axis extended 120 km (74 miles) to the southeast and 80 km (49 miles) to the northwest with a 100 km (62 miles) minor axis. The major axis was elongated in the direction of prevailing winds. To the north, the Yellowstone River transects the ellipse from near Custer to slightly east of Miles City; the perimeter of the ellipse extends about 27 km (17 miles) north of Forsyth. To the west, the boundary roughly follows the Bighorn River-Rotten Grass Creek and enters Wyoming south of the Tongue River Reservoir. The eastern boundary extends southeast from Miles City to Mizpah Creek in Custer County and then south to Broadus. The ellipse contains an area of about 20,100 square km (10,800 square miles).

The water quantity investigation was conducted primarily within the same study area.

The study area was separated into eight stream segments:

1) The Little Bighorn-Bighorn Rivers and tributaries--Tullock, Rotten Grass, Soap, Beauvais, Owl, Lodge Grass, Reno and Pass Creeks.

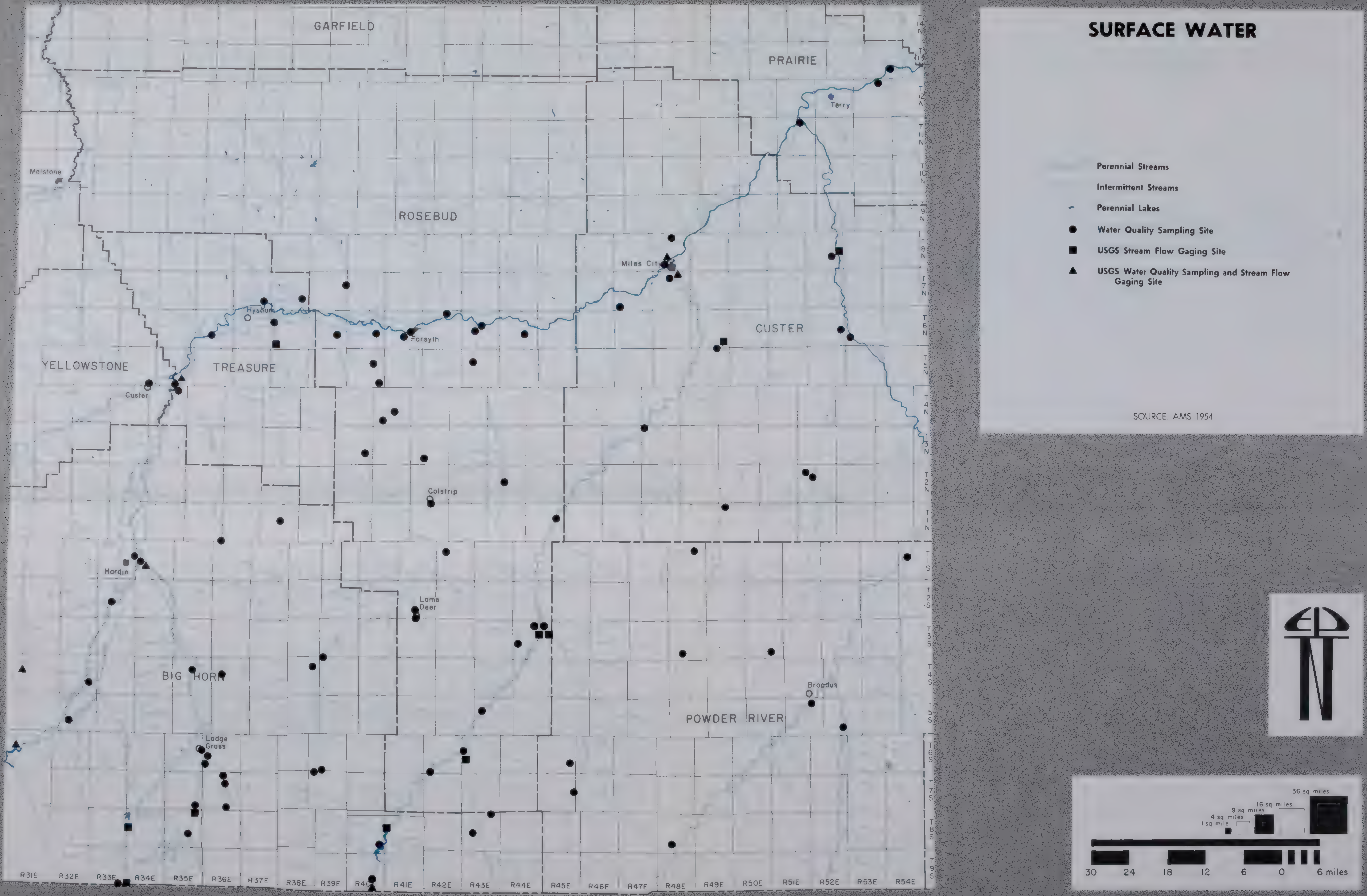
2) Small tributaries to the Yellowstone River—Froze-to-Death, Great Porcupine, Little Porcupine, Sunday, Reservation, Sarpy, Sweeney, Moon, Starve-to-Death, and Smith Creeks.

3) Armells Creek

4) Yellowstone River from Custer to Miles City

5) Rosebud Creek and tributaries--Lame Deer, Muddy, Davis, and Indian Creeks.

SURFACE WATER



Perennial Streams

Intermittent Streams

Perennial Lakes

● Water Quality Sampling Site

■ USGS Stream Flow Gaging Site

▲ USGS Water Quality Sampling and Stream Flow Gaging Site

SOURCE: AMS 1954

6) Tongue River and tributaries--Pumpkin, Otter, Hanging Woman, Squirrel, and Youngs Creeks.

7) An upstream segment of the Powder River and tributaries--Mizpah Creek and the Little Powder River.

8) Yellowstone River from Miles City to the North Dakota state line.

Most of the study area is in the eastern two-thirds of what is designated by HES as the Middle Yellowstone Water Quality Management Basin; a small portion extends into the southwestern segment of the Lower Yellowstone Water Quality Management Basin. The Middle Yellowstone Water Quality Management Basin generally includes the area from Huntley, Montana, downstream to Miles City and southward from the Yellowstone River to the Wyoming state line. The Lower Yellowstone Water Quality Management Basin extends from Miles City to the North Dakota state line and southward to the Wyoming state line but excludes a small area in the southeastern part of Montana that is drained by the Little Missouri River. The study area includes most of Rosebud and Treasure Counties, a small part of Yellowstone County around Custer, the eastern two-thirds of Big Horn County, and the western halves of Custer and Powder River Counties; the lower Yellowstone River mainstem segment extends into Prairie, Dawson and Richland Counties.

Gaging stations, Water Quality Bureau sampling sites, miscellaneous sampling sites, and USGS water quality stations are listed in Tables 1 through 4 of Appendix B2, and are plotted on the Surface Water Map.

B. Water Quantity

1. Watershed Descriptions, Flow Regimens, and Precipitation-Runoff Relationships

Hydrologic characteristics of study area streams are summarized in Tables 10-15 and 10-16 and Figures 10-13 through 10-17.

Many of the smaller tributaries in the study area (see Table 2 in Appendix B3) are intermittent; that is, they flow during only part of the year. Streamflow data for most of the larger perennial streams were acquired from the USGS. Other sources of streamflow data were the DNRC and the Montana Water Quality Bureau. Streamflow records and characteristics are summarized in Table 10-15.

For most streams in the Middle Yellowstone Basin, there are considerable variations in daily, monthly, and annual discharge. An examination of streamflow data for the study area indicates that spring runoff in low elevation tributaries occurs between March and early May. A minor peak in discharge in the Yellowstone River occurs during this period. During this spring runoff period, a major portion of the annual flow occurs for tributary streams of the Yellowstone, Bighorn, Tongue, and Powder Rivers. For the large rivers, however, the major peak flow and the majority of the annual discharge occurs from mid-June to mid-July; June is the period of maximum flow. Runoff from the snow pack in the mountainous portion of the drainage is the principal water source.

Many smaller streams in the area have their peak discharges in midwinter and early spring,

TABLE 10-15

HYDROLOGICAL CHARACTERISTICS OF MAJOR STREAMS IN THE STUDY AREA

STATION AND LOCATION	DRAINAGE AREA (Square Miles)	DISCHARGE (cfs) Avg. Annual	Max. Annual	Min. Annual	SIGNIFICANT FLOW PERIODS Avg. for Min. Month	Avg. for Max. Month	YEARS OF RECORD
Yellowstone River at Billings 01N 26E 34AA	11,795	6,858	66,100	430	2,377 (Jan.)	26,500 (June)	45
Bighorn River at Bighorn 05N 34E 33AA	6,000 (in Montana)	3,851	26,200	400(2)	3,074 (Sept.)	7,554 (June)	27
Little Bighorn River near Hardin 01S 34E 19AA	1,101	285	4,520	0.2			19
Lodge Grass Creek near Wyola 08S 34E 19BB	80.7	49.1	1,130	3.0	13.4 (Jan.)	200 (June)	33
Little Bighorn River near Wyola 07S 35E 35AC	253	205	3,630	12			32
Pass Creek near Wyola 09S 35E 13A	20 (in Montana)	36.1		0	7.0 (Aug.)	65.2 (May)	18
Little Bighorn River at state line 09S 33E 36CB	193 (0 in Montana)	150	2,730	21			33
Beauvis Creek near St. Xavier 04S 30E 15BC	100	18.7	1,600	0.5	4.7 (Dec.)	50.9 (May)	5
Rotten Grass Creek near St. Xavier 05S 33E 07A	147	31.2	700	2.6	10.2 (Oct.)	74.1 (May)	15 (intermittent)

TABLE 10-15

HYDROLOGICAL CHARACTERISTICS OF MAJOR STREAMS IN THE STUDY AREA (cont.)

STATION AND LOCATION	DRAINAGE AREA (Square Miles)	DISCHARGE (cfs)			SIGNIFICANT FLOW PERIODS		YEARS OF RECORD
		Avg. Annual	Max. Annual	Min. Annual	Avg. for Min. Month	Avg. for Max. Month	
Soap Creek near St. Xavier 06S 32E 10A	98.3	30.6	2,980	1.0	20.8 (Dec.)	71.5 (May)	21 (intermittent)
Bighorn River near St. Xavier 06S 31E 16BA	3,500 (in Montana)	3,550	24,800	111(2)			38
Rosebud Creek near forsyth 05N 42E 09C	1,270	24	596	0	6.4 (Sept.)	84.3 (March)	6
Tongue River at Miles City 07N 47E 23D	3,902	423	13,300	0	164 (Dec.)	1,843 (June)	29
Tongue River near Ashland 01S 44E 10BD	2,353	610	5,740	50			6
Tongue River at Dam 08S 40E 13A	293	449	7,340	0 (Dam closure)			33
Tongue River at state line 09S 40E 33BA	0 (in Montana)	493	2,590	3.9			12
Yellowstone River at Miles City 08N 47E 38BC	10,600 (approximately)	11,330	96,300	996	6,921 (Dec.)	43,250 (June)	45
Powder River near Locate 08N 51E 14BC	13,194	620	31,000	0	111 (Dec.)	2,609 (June)	34

TABLE 10-15

HYDROLOGICAL CHARACTERISTICS OF MAJOR STREAMS IN THE STUDY AREA (Cont.)

STATION AND LOCATION	DRAINAGE AREA (Square Miles)	DISCHARGE (cfs) Avg. Annual	Max. Annual	Min. Annual	SIGNIFICANT FLOW PERIODS Avg. for Min. Month	Avg. for Max. Month	YEARS OF RECORD
Little Powder River near Broadus 05S 52E 21BA	1,974	39.6	2,700	0			22
Powder River at Moorhead 09S 48E 08B	8,088	453	7,800	60	136 (Dec.)	2,113 (June)	43
Yellowstone River at Sidney 22N 59E 09CAC	69,103	13,030	159,000	470	7,238 (Dec.)	45,972 (June)	60

TABLE 10-16

MONTHLY AND ANNUAL MEAN FLOWS
(CFS)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Little Bighorn River Near Hardin 062940 1953-1972	144.8	151.9	123.5	119.4	197.6	366.4
Tongue River at Miles City 063085 1938-1942 1946-1972	233.4	259.1	182.9	161.4	264.7	580.8
Yellowstone River at Miles City 063090 1929-1972	8,911.2	6,891.6	5,371.0	4,815.1	5,929.6	5,434.3
Tongue River Below Hanging Creek 42C-020.00 1966-1972	313	229	---	---	---	---
Rosebud Creek at Rosebud 062960 1938-1943 1948-1954	7	5	5	4	34	87
Bighorn River at Bighorn 062947 1945-1972	3240	3100	2914	2767	3071	3781
Pass Creek 062905	189.6	126.2	112.6	105.0	127.0	161.6
Powder River at Moorhead 063245 1930-1972	187.3	208.3	159.1	137.7	285.0	692.4

TABLE 10-16

MONTHLY AND ANNUAL MEAN FLOWS (Cont.)
(CFS)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Little Powder River near Broadus 063255 1951-1972	6.6	4.4	4.0	3.7	48.2	159.2
Powder River near Locate 063265 1939-1972	185	179	143	115	473	1518
Yellowstone River at Billings 062145 1929-1972	3872	3493	2718	2417	2654	3025
Yellowstone River near Sidney 063295 1911-1972	8374	7255	5689	5400	6650	11,491
Bighorn River at State Line 062890 1939-1972	87.5	76.4	68.1	62.5	62.2	61.9

TABLE 10-16

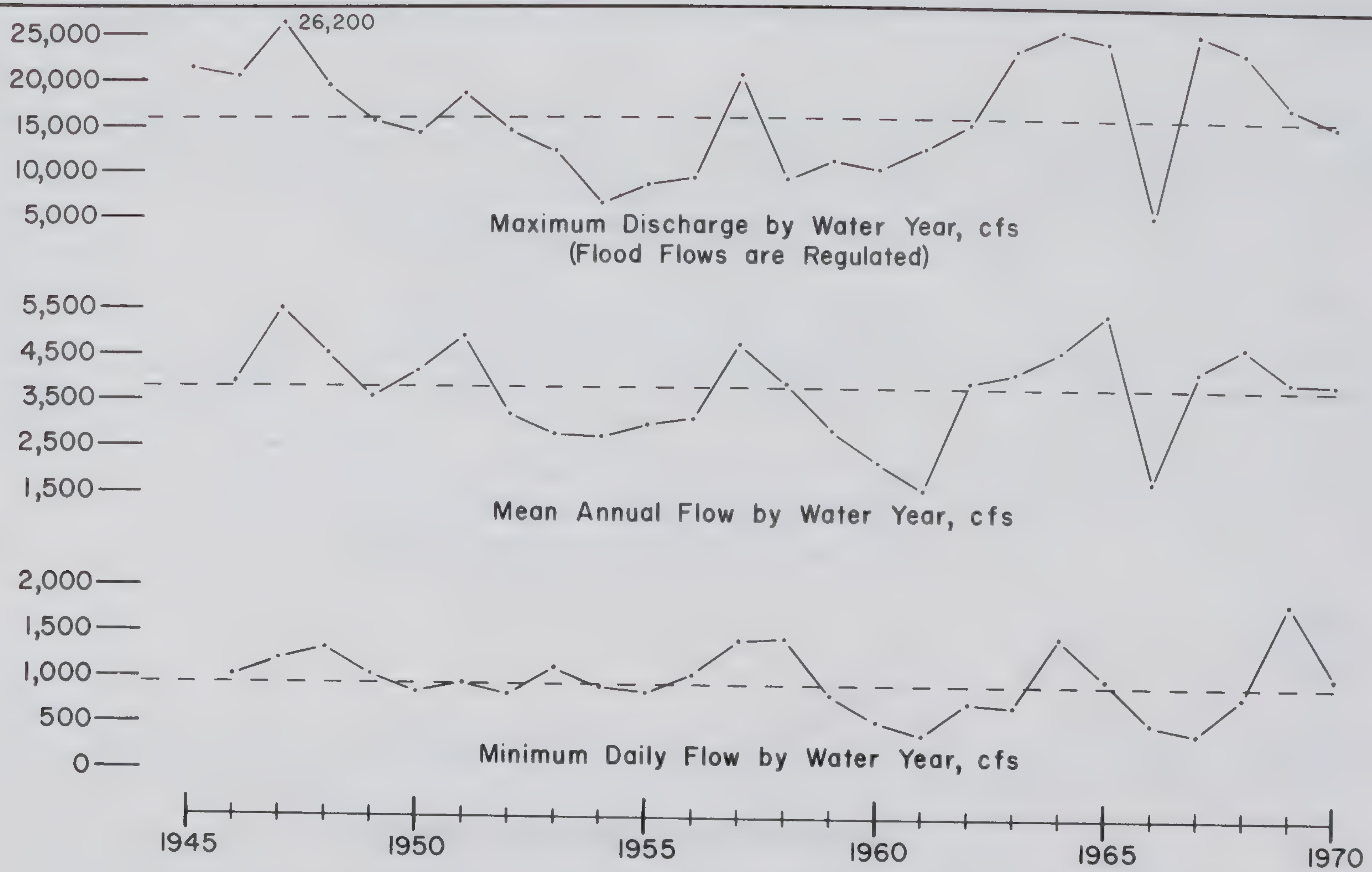
MONTHLY AND ANNUAL MEAN FLOWS (Cont.)
(CFS)

	April	May	June	July	Aug.	Sept.	MEAN ANNUAL
Little Bighorn River Near Hardin 062940 1953-1972	334.7	525.8	910.5	258.8	113.1	127.9	285
Tongue River at Miles City 063085 1938-1942 1946-1972	488.7	645.3	627.5	679.1	130.7	177.8	423
Yellowstone River at Miles City 063090 1929-1972	8,139.8	17,228,3	14,794.0	20,990.9	7,946.5	7,043.3	11,330
Tongue River Below Hanging Creek 42C-020.00 1966-1972	602	1129	2278	743	436	426	---
Rosebud Creek at Rosebud 062960 1938-1943 1948-1954	44	25	40	21	8	6	35.8
Bighorn River at Bighorn 062947 1945-1972	3407	4531	8588	5900	2521	2791	3,851
Pass Creek 062905 1940-1972	191.3	440.3	693.5	239	114	118	205
Powder River at Moorhead 063245 1930-1972	640.7	1046.7	1396.4	498.3	168.3	134.6	453

TABLE 10-16

MONTHLY AND ANNUAL MEAN FLOWS (Cont.)
(CFS)

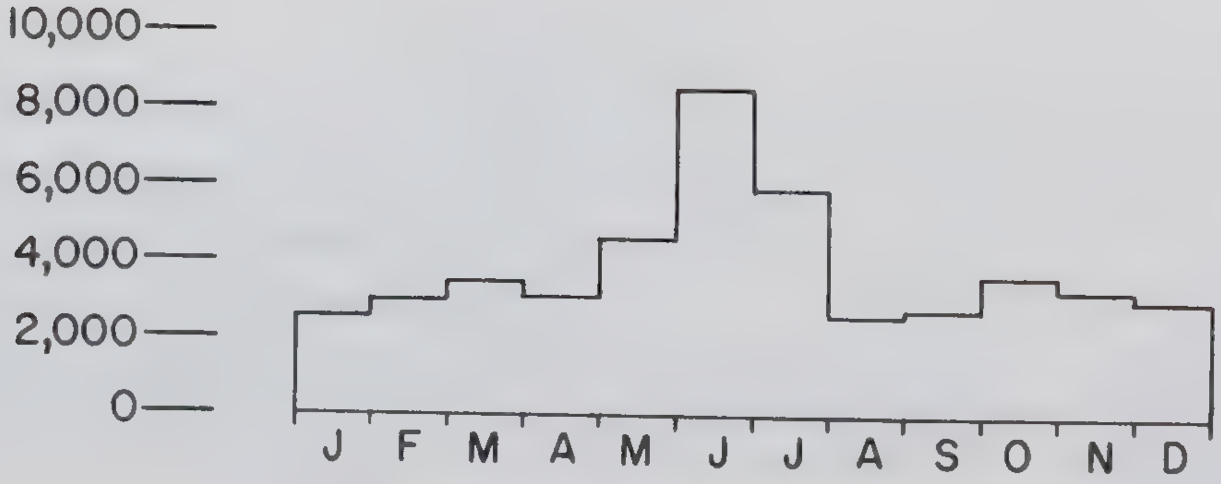
	April	May	June	July	Aug.	Sept.	MEAN ANNUAL
Little Powder River near Broadus 063255 1951-1972	63.1	52.9	84.5	29.4	12.2	7.2	39.6
Powder River near Locate 063265 1939-1972	885	1166	2014	681	226	169	620
Yellowstone River at Billings 062145 1929-1972	4023	11,817	25,313	13,258	5129	4006	6,858
Yellowstone River near Sidney 063295 1911-1972	11,038	18,769	42,875	25,005	9,219	7,229	13,030
Bighorn River at State Line 062890 1939-1972	84.7	316.4	534.9	219.2	122.8	103	150.2



Maximum Discharge by Water Year, cfs
(Flood Flows are Regulated)

Mean Annual Flow by Water Year, cfs

Minimum Daily Flow by Water Year, cfs

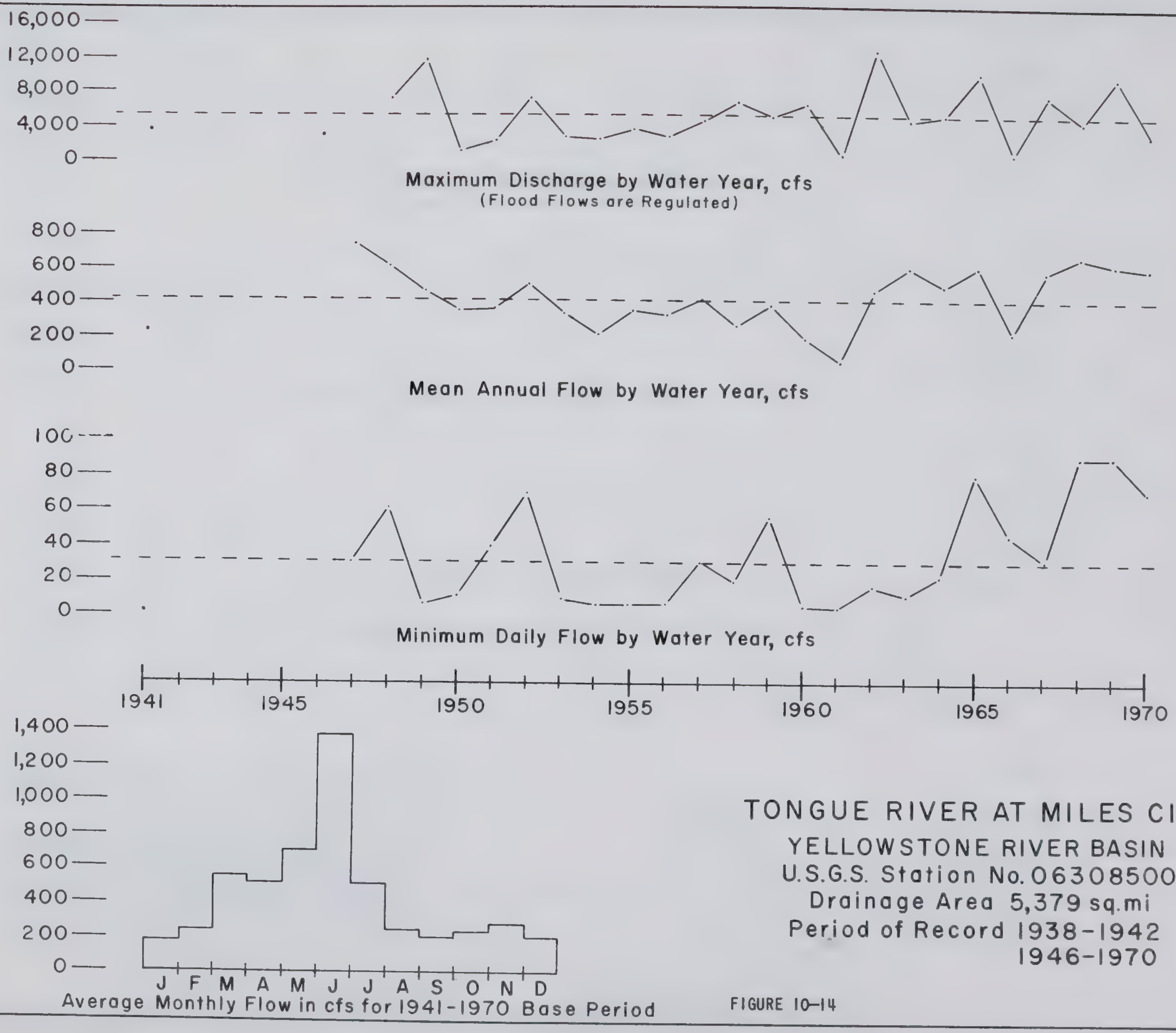


Average Monthly Flow in cfs
for 1946-1970 Base Period

BIG HORN RIVER AT BIG HORN

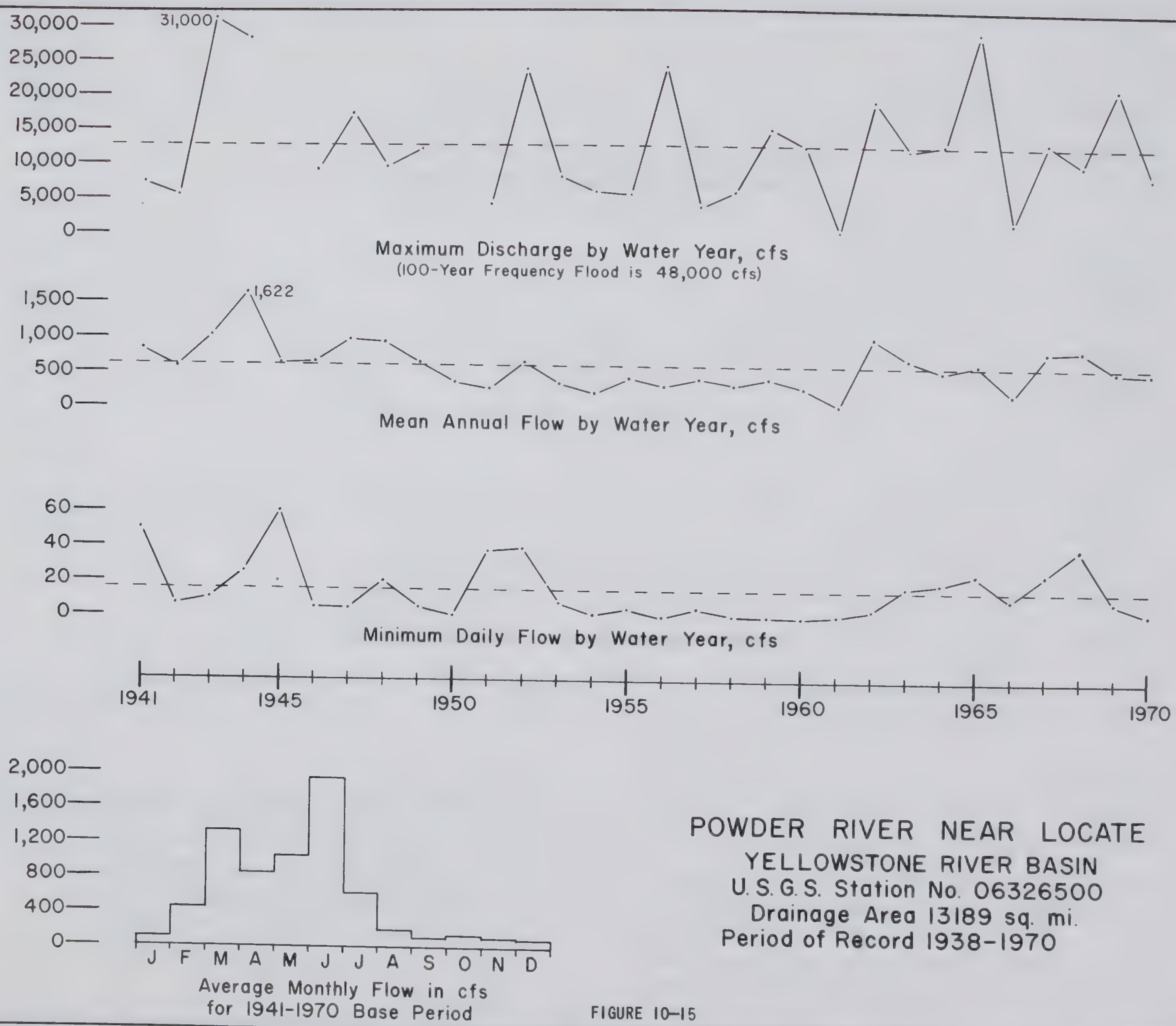
YELLOWSTONE RIVER BASIN
U. S. G. S. Station No. 06294700
Drainage Area 22885 sq. mi.
Period of Record 1945-1970

FIGURE 10-13



TONGUE RIVER AT MILES CITY
YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06308500
Drainage Area 5,379 sq.mi
Period of Record 1938-1942
1946-1970

FIGURE 10-14



Maximum Discharge by Water Year, cfs
(100-Year Frequency Flood is 48,000 cfs)

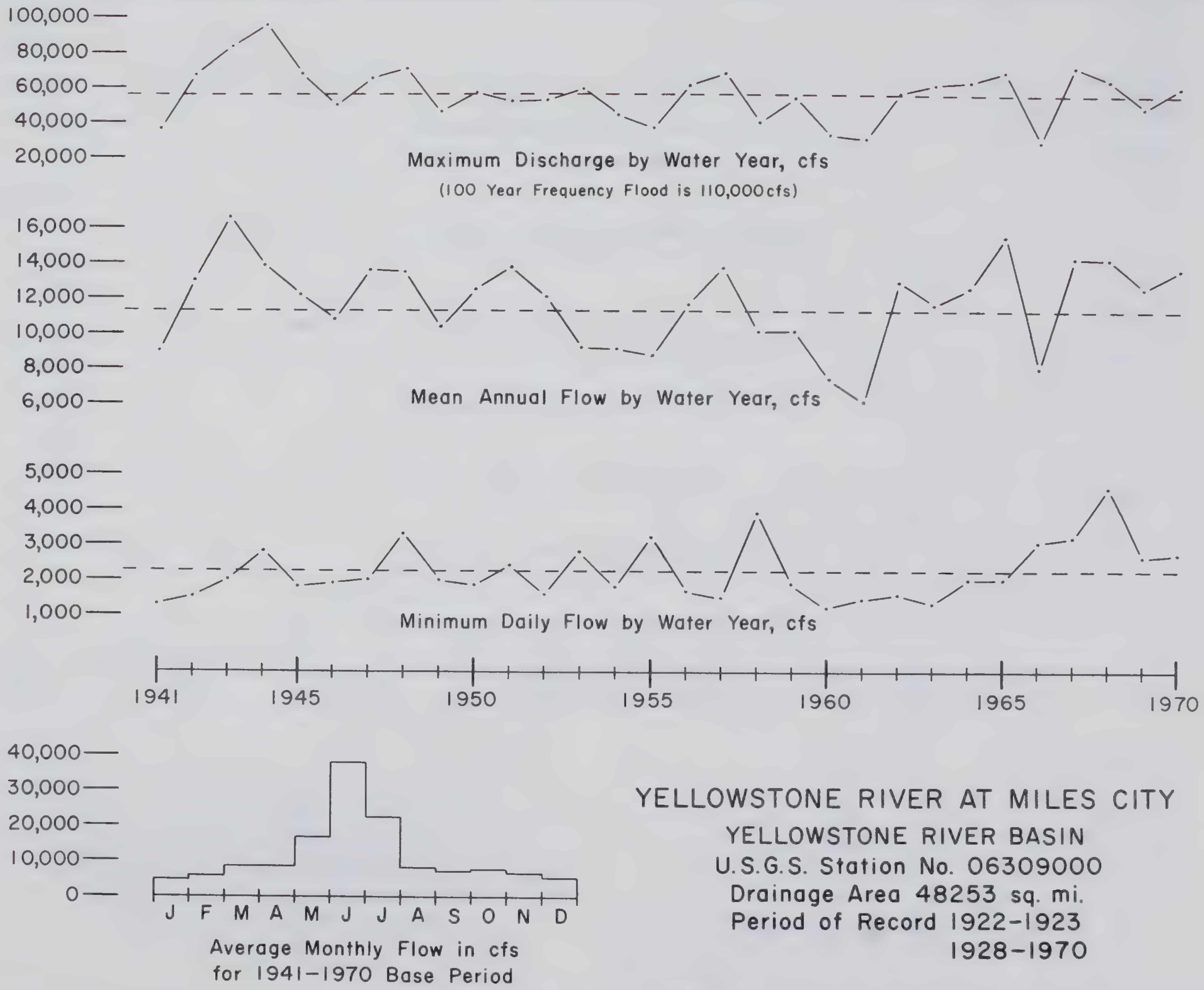
Mean Annual Flow by Water Year, cfs

Minimum Daily Flow by Water Year, cfs

Average Monthly Flow in cfs
for 1941-1970 Base Period

POWDER RIVER NEAR LOCATE
YELLOWSTONE RIVER BASIN
U. S. G. S. Station No. 06326500
Drainage Area 13189 sq. mi.
Period of Record 1938-1970

FIGURE 10-15



Maximum Discharge by Water Year, cfs
(100 Year Frequency Flood is 110,000cfs)

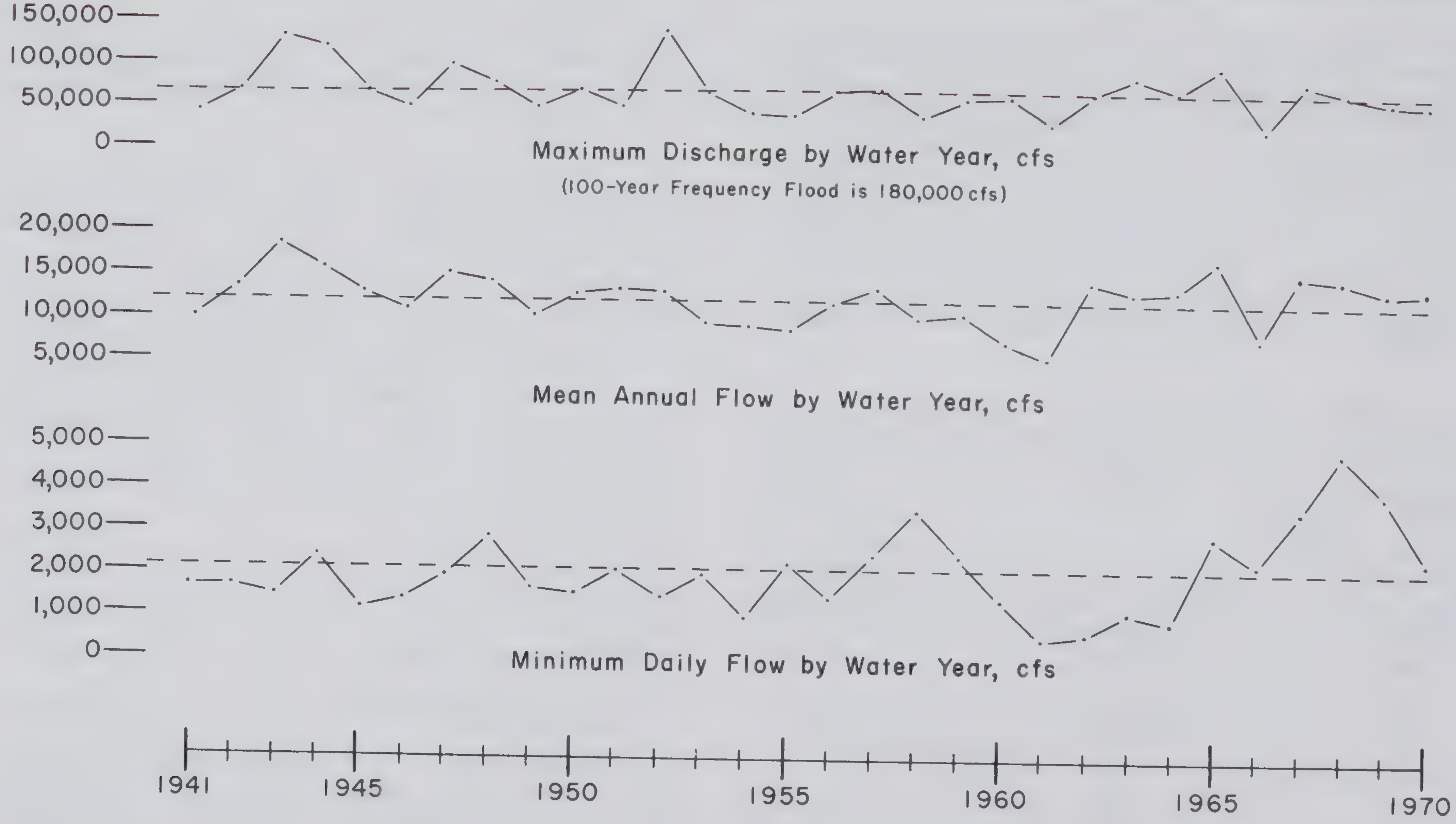
Mean Annual Flow by Water Year, cfs

Minimum Daily Flow by Water Year, cfs

Average Monthly Flow in cfs
for 1941–1970 Base Period

YELLOWSTONE RIVER AT MILES CITY
YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06309000
Drainage Area 48253 sq. mi.
Period of Record 1922–1923
1928–1970

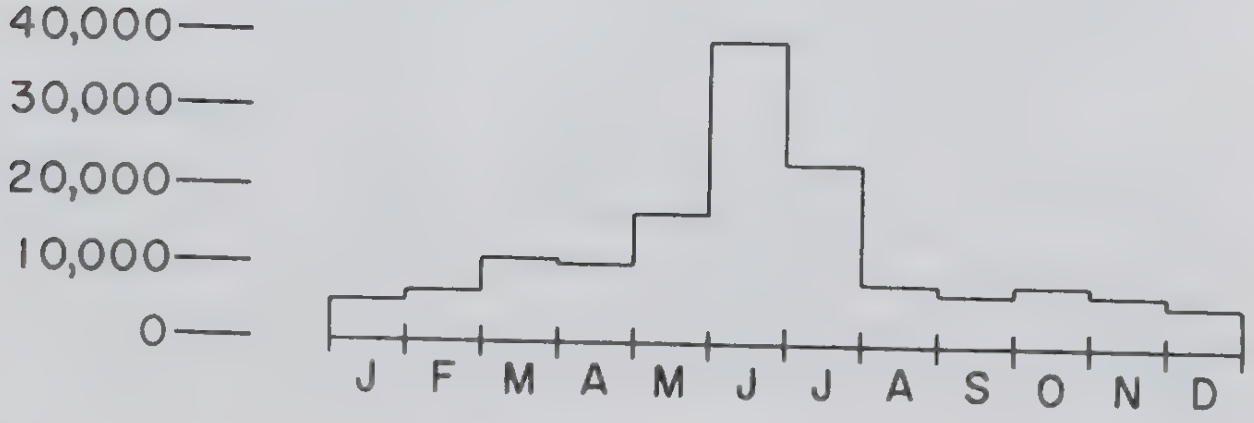
FIGURE 10–16



Maximum Discharge by Water Year, cfs
(100-Year Frequency Flood is 180,000 cfs)

Mean Annual Flow by Water Year, cfs

Minimum Daily Flow by Water Year, cfs



Average Monthly Flow in cfs
for 1941–1970 Base Period

YELLOWSTONE RIVER NEAR SIDNEY

YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06329500
Drainage Area 68812 sq. mi.
Period of Record 1910–1931
1933–1970

FIGURE 10–17

due to warm chinook weather. In addition, significant flows can result from heavy summer rain storms, characteristic of a prairie area with a semi-arid climate. Sparse vegetation in much of the basin and soils with low infiltration rates produce conditions favorable for rapid runoff and rapid changes in streamflow. Average annual runoff for most of the study area is relatively low, from 0.25 to 0.50 inches. In mountainous headwaters of the major rivers, this factor approaches 5.0 inches (U.S. Bureau of Reclamation 1972).

The Yellowstone River is essentially a free-flowing river from its origin in the mountains to its confluence with the Bighorn River. Yellowtail Dam has regulated flows in the Bighorn since 1966. Except during spring runoff in the Yellowstone River, the Bighorn River has nearly as great a flow as the Yellowstone above its confluence with the Bighorn. Thus, the Yellowstone River below its confluence with the Bighorn is significantly regulated during much of the year.

Below is a list of the lowest and highest recorded flows at three USGS gaging stations on the Yellowstone.

> USGS STA 062145 Yellowstone River at Billings. Lowest recorded flow was 450 cubic feet per second (cfs) in December of 1932. Highest recorded flow was 66,100 cfs on June 16, 1967.
>
> USGS STA 063090 Yellowstone River at Miles City. Lowest recorded flow was 996 cfs in December of 1932. Highest recorded flow was 96,300 cfs on June 19, 1944.
>
> USGS STA 063295 Yellowstone River at Sidney. Lowest recorded flow was 470 cfs in May of 1961. Highest recorded flow was 159,000 cfs on June 2, 1921.

The Powder and Tongue Rivers have similar streamflow characteristics, and their discharges do not appreciably increase or decrease between the Montana state line and their confluence with the Yellowstone River. Regulation by the Tongue River Reservoir reduces annual flow fluctuations on the Tongue River. Minimum flow in the Tongue and Powder Rivers usually occurs in December, and maximum flows in June. Figures 10-13 through 10-17 provide maximum discharge, mean annual flow, minimum daily flow, and average monthly flow information for the Bighorn, Tongue, Powder, and Yellowstone Rivers.

Most small tributaries of the area are sustained by groundwater inflow and are significantly influenced by snow melt, rain storms, and irrigation diversions.

2. Surface Water Usage

Water usage, and particularly waste flows associated with water usage, have significant water quality impacts. Water uses of principal interest in the study area are municipal and industrial water supply and irrigation.

The primary cultural use of water in the study area is irrigation. Approximately 240,000 acres of irrigated lands utilize about 674,660 acre-feet of water per year from the Yellowstone River system (Table 10-17). A portion of the irrigation has been developed privately through

TABLE 10-17

IRRIGATION WATER USE
(all figures in acre feet per year)

County	Acres Irrigated	Diversion Requirement	Net Depletion	Return Flow
Big Horn	65,569	394,334	185,929	208,405
Custer	30,043	202,277	95,374	106,903
Dawson	18,579	118,347	55,801	62,546
Powder River	21,963	131,527	62,015	69,512
Prairie	12,042	71,257	33,598	37,659
Richland	40,795	223,306	105,289	118,017
Rosebud	24,857	158,649	74,803	83,846
Treasure	20,285	131,180	61,851	69,329
TOTAL	234,133	1,430,877	674,660	756,217

(DNRC Unpublished #1)

the construction of diversions, small dams, and reservoirs. State and federal water development projects have provided facilities for the majority of the irrigation along the Yellowstone River.

Major Montana Water Resources Division projects in the area are the Hysham Bench Unit and the Tongue River Reservoir. About 20,000 acres of irrigated land receive supplemental water from these two projects. The Tongue River Reservoir is located about 10 miles north of the Montana-Wyoming border near Decker and the Hysham Bench project is located near Hysham south of the Yellowstone River. The Tongue River Reservoir has a capacity of 69,439 acre-feet; 38,835 acre-feet are contracted to agricultural and 4,175 acre-feet to industrial use. Recreation, such as boating, fishing, and various water sports, is an important use of the reservoir. The Sidney Pumping Project, constructed in 1938, provides irrigation water to 3,200 acres of land near Sidney.

The Bureau of Reclamation is involved in a number of irrigation and irrigation-related projects, including the Huntley Irrigation Project and Yellowtail Dam (Bighorn Reservoir). About 24,000 acres of land along the Yellowstone River downstream of Huntley are served by the Huntley Irrigation Project. Yellowtail Dam houses four 62.5 megawatt generating units. These units produce an average of one billion kilowatt-hours of energy annually. Water taken directly from Bighorn Reservoir was projected by the Bureau of Reclamation to irrigate 43,500 acres of land in the Hardin area; however, no land has yet been irrigated. Land near Hardin is under irrigation from water stored in the afterbay of the dam via the Bighorn Canal. In addition to power generation and water retention for irrigation, this reservoir provides recreational opportunities for fishing, camping, boating, and wildlife observation. About 700,000 acre-feet of water have been optioned for industrial use. The Crow Irrigation Project (Bureau of Indian Affairs) provides water for nearly 30,000 acres of land on the Crow Indian Reservation.

The Bureau of Reclamation constructed the Buffalo Rapids Irrigation Project, which supplies water to over 25,000 acres of land from Miles City to Glendive along the Yellowstone River. This project undergoes frequent expansion as new land is developed throughout the system. The Lower Yellowstone Project, constructed by the Bureau of Reclamation, provides an irrigation capacity for about 33,000 acres of land in Dawson and Richland Counties. The Missouri River Basin Project, designed and constructed to serve highlands adjacent to the Lower Yellowstone Project, provides water to 2,300 acres of land. In addition, the Intake Canal furnishes water to 800 acres of land above the Main Canal of the Lower Yellowstone Project.

Most of the water diversions from the Yellowstone River and tributaries are accomplished by means of gravity or pump systems. Some groundwater is utilized for irrigation but at a nearly negligible amount relative to surface water use.

Eleven towns in the study area use a total of 3,534 acre-feet of municipal water per year for public supplies. About 85% of the municipal water for the urban centers is derived from surface water. In contrast, about two-thirds of the municipally diverted water for public supply below Miles City is obtained from groundwater.

Only Glendive uses surface water from the Yellowstone River, with 85% of their municipal supply obtained from this source.

Rural water supplies are largely derived from groundwater. It is estimated that about 1,300 acre-feet per year (420 million gallons) of groundwater are used for this purpose in the study area. Livestock water is derived from both ground and surface water. This use is estimated to exceed rural human consumption by a ratio of about 2.5 to 1.

Industrial water use (Table 10-18) accounts for about 30 million gallons per day in the study area. The majority of this water is derived from the Yellowstone River and is used non-consumptively for cooling of small power generation plants at Sidney and Glendive. Consumption use from the Yellowstone ranges from 0.2 to 1 million gallons per day (224 to 1,120 acre-feet per year).

Water use in the basins will continue to grow as coal development for energy production becomes an increasingly larger user of water resources. Irrigation demands are expected to increase also. This increase will be primarily through an increase in the use of sprinkler systems that use water from both surface and groundwater sources. With expected population increases that are predicted to accompany the coal energy developments, municipal demands will markedly increase, as well as the demand for a greater wastewater dilution capacity in receiving waters.

C. Water Quality

In addition to water quality data obtained directly in this study, water quality information available from other sources were compiled and assessed. Of major value were the data gathered by the USGS. Water quality information is summarized in yearly bulletins available from the USGS. Of most interest were the years 1965-1972. Water quality data from the USGS for the years 1947-1965 were also reviewed, although there is little data available for this period.

Water quality data obtained from other investigations of the Montana Water Quality Bureau apart from this study were also considered, including information collected as part of appropriate Water Quality Management Plans, studies on the water quality in the Yellowstone River, and surveillance programs.

Finally, assessments were also directed towards information contained in any appropriate reports, environmental impact statements, and publications. As examples, the Westinghouse Environmental Systems' Colstrip Generation and Transmission Project, Applicant's Environmental Analysis (1973) includes some water quality information, as does the strip mining statements prepared by Peabody Coal Company and Western Energy Company. Some information is also available in an EIS prepared by the Air Quality Bureau on the initial generation development at Colstrip (Units 1 and 2). Various reports prepared by the Montana Agricultural Experiment Station at MSU also contain some water quality

TABLE 10-18

SELF-SUPPLIED INDUSTRIAL WATER USE
(Including Thermoelectric)

County	Million Gallons Per Day Surface Water	Million Gallons Per Day Ground Water	Million Gallons Per Day Total	Acre Feet Per Year
Big Horn	1.010		1.010	1,131
Custer		.436	.436	488
Dawson	1.000*		1.000	1,122
Powder River	.008		.008	9
Prairie			0	0
Richland	31.175*	.048	31.223	34,969
Rosebud	.049		.049	55
Treasure			0	0
TOTAL	33.242	.484	33.726	37,774

*Includes water for thermoelectric use

(DNRC Unpublished #2)

data. Reports generated from the Northern Great Plains Resources Program were reviewed; the publications of Wright and Soltero (1973) and Donohue and Ashley (1973) were also considered in relation to the study.

1. Water Quality Parameters

Water quality parameters examined in this investigation were selected first to define the general baseline water quality in the area, and second, to obtain data on those water quality characteristics that could be affected by the construction, operation, and maintenance of Units 3 and 4 at Colstrip. Parameters examined (Table 10-19) included chemical, physical, and biological characteristics of the water. The chemical constituents include major anions and cations present in dissolved state in the water, secondary dissolved constituents, dissolved toxic metals, and nutrients. Physical characteristics of the waters that were examined included the material in suspension, the specific conductivity of the water, and pH. Biological parameters selected were fecal coliform, total coliform, and fecal strep. In addition, some sampling sites were examined for their biological conditions (BOD_5, coliforms, etc.), and a qualitative biological assessment was made that would define the water quality in the stream. Oxygen-related parameters that were examined as part of this investigation include dissolved oxygen (DO) and five-day biochemical oxygen demand (BOD_5).

2. Discharges to Study Area Streams

Wastes generated from water usage in the basin include industrial and municipal wastes and irrigation return flows. Currently there are 22 potential municipal wastewater discharges. Of these, 17 are major municipal discharges from communities, with the rest minor discharges, such as cafes, trailer courts, and housing developments. Of the major municipalities, Hysham, Colstrip, Forsyth, Rosebud, Miles City, Terry, and Glendive are of most interest to this study, due to their close proximity to the coal developments. Impacts resulting from predicted population increases are expected to be greatest in these communities. In addition, the community of Billings is expected to have a major population increase. Table 10-20 summarizes information relative to current community wastewater treatment facilities for communties along the Yellowstone, and Table 10-21 summarizes waste source quantity and quality data.

In addition to community wastewater effluents, several discharges from water treatment plants have been identified in the study area. Settling ponds and flocculation chambers and filters are cleaned periodically by flushing collected sediment and sludge back into streams. These discharges receive no treatment before discharge. The communities of Forsyth, Hardin, St. Labre, Crow Agency, Hysham, Miles City, and Glendive discharge such wastes. The Montana-Dakota Utilities generating plant in Sidney also discharges water treatment wastes. The community of St. Labre does have three post-treatment settling ponds that allow settling of solids before stream disposal. No water quantity or quality data have been obtained on these discharges.

There are 12 industries in the study area (Table 10-22); Five of these presently do not have discharges received by state waters,

TABLE 10-19: Summary of Water Quality Parameters Monitored.*

	MAJOR-MINOR CONSTITUENTS	COMMON METALS	NUTRIENTS
Helena Laboratory	Calcium Magnesium Sodium Chloride Sulfate Carbonate Bicarbonate Hydroxide *Boron *Fluoride *Potassium	*Arsenic Cadmium *Chromium Copper Iron *Lead *Manganese Mercury Zinc *Beryllium *Cobalt *Lithium *Selenium *Vanadium	Nitrate (1) Ortho-P (1) *Total-P
Field and Branch Laboratory	Calcium *Chloride *Sulfate *Carbonate *Bicarbonate		

*Parameters that were infrequently tested on occasional samples are denoted by an asterisk.

TABLE 10-19 (cont.)

Summary of water quality parameters monitored through the study. Parameters that were infrequently tested on occasional samples are denoted by an asterisk.

ADDITIONAL CHEMICAL	PHYSICAL	CALCULATED	OXYGEN AND BIOLOGICAL
(2) Tot. Hard.	(3) *T. Non. F. Res.	(5) SAR	(10) *TOC
(2) Tot. Alk.	(4) *Lab. Turb.	(6) Dil. Sp. Cond.	
Lab. pH	(11) Lab. K_{25}	(7) Carb. Hard.	
		(8) N. Carb. Hard.	
		(9) Diss. Sol.	
(2) Tot. Hard.	Temperature	Magnesium	(14) DO
(2) Tot. Alk. pH	(11) K_{25}		(15) BOD_5
	(12) TSS Turbidity		(16) Fecal Col.
	(13) *Set. Sol. Flow		*Fecal Streps
			(16) *Total Col.
			(17) *Bio. Asses.

1. Ortho and Total Phosphate
2. Total Hardness and Total Alkalinity
3. Total Non-filterable Residue
4. Laboratory Turbidity
5. Sodium Adsorption Ratio
6. Calculated Dilute Specific Conductance
7. Carbonate Hardness
8. Non-carbonate Hardness
9. Dissolved Solids
10. Total Organic Carbon
11. Specific Conductance (25C)
12. Total Suspended Solids (Residue)
13. Settleable Solids
14. Dissolved Oxygen
15. Five-day Biological Oxygen Demand
16. Fecal and Total Coliforms
17. Biological Assessment

TABLE 10-20

MUNICIPALITY	POPULATION (Estimates)	TREATMENT FACILITY	APPROX. LAGOON ACRES	RECEIVING WATERS	DISCHARGE	PROJECTED POPULATION INCREASE
St. Labre	250(?)	2-cell lagoon	2.0	Tongue River	Intermittent	Slight
St. Xavier	75	2-cell lagoon		Rotten Grass Creek	Continuous	Slight
Billings	61,600	Primary	---	Yellowstone River	Continuous	Large
Glendive	7,500	3-cell lagoon	65.0	Yellowstone River	Continuous	Moderate
West Glendive	1,500	2-cell lagoon	26	Yellowstone River	Continuous	Moderate
Terry	375	2-cell lagoon	13.25	Yellowstone River	Intermittent	Moderate
Fallon	275	1-cell lagoon	3	None	None	Slight
Savage	75	1-cell lagoon	1.5	None	None	Slight
Sidney	4,543	2-cell lagoon	71	None	None	Moderate

TABLE 10-21

NAME OF WATER SOURCE	AVERAGE DAILY FLOW	BOD$_5$ mg/l	BOD$_5$ #/day	BOD$_5$ %Reml.	TSS mg/l	TSS #/day	TSS %Reml.	pH	FECAL COLIFORM No./100 ml
Forsyth	0.05	103	39.6	60.1	20.0	7.7	94.1	7.40	2.5×10^4
Rosebud									
Ashland Mutual Self-Help	None								
St. Labre Mission School	0.01								
Lame Deer	0.65	40.0	200	89.0	40	200	84.1	8.00	1.3×10^5
Busby	None								
Colstrip	None								
Lodge Grass	0.01	60	46.1	79.0				7.60	1.9×10^4

TABLE 10-21
(continued)

NAME OF WATER SOURCE	AVERAGE DAILY FLOW	BOD5 mg/l	BOD5 #/day	BOD5 %Reml.	TSS mg/l	TSS #/day	TSS %Reml.	pH	FECAL COLIFORM No./100 ml
Crow Agency	0.08	73.0	40	81	21.7	10		7.5	10^4
Hardin	0.10	83.0		55	47.5			7.55	1.8×10^5
St. Xavier	0.005	300	10	63	23.2	0.9		7.80	2.0×10^4
Miles City	0.3	75	194		20	50.2			
Terry	0.04	47.0	15.8	72	16	5.4	80		2.5×10^3
Fallon	0.01								
West Glendive	0.05	33	14		5.3	2.3			230 MPN/1
Glendive	0.17	87	128	78	66	97	90		4.8×10^4
Savage									
Sidney	None								
Custer	None								
Hysham	0.04	32.6	10.0	88.7	105	32.3	30.7	7.60	2.0×10^5

Abbreviations:
= lb = pounds
%Reml. = percent removal
BOD_5 = 5-day biochemical oxygen demand
MPN = most probable number

TABLE 10-22

SUMMARY OF INDUSTRIAL WASTE TREATMENT FACILITIES IN THE STUDY AREA

INDUSTRY AND LOCATION	TYPE OF DISCHARGE	TREATMENT FACILITY	RECEIVING WATERS	DISCHARGE CHARACTERISTICS
Soap Creek Assn., Inc. St. Xavier, Montana	Oil field production water	3 skim ponds	Soap Creek	Intermittent
Westmoreland Resources, Hardin, Montana	Strip mining runoff, groundwater discharge	storm drainage settling pond	Sarpy Creek	Intermittent
Peabody Coal Co., Colstrip, Montana	Strip mining runoff, groundwater discharge	series of settling pits	none	not applicable
Western Energy, Colstrip, Montana	Strip mining runoff, groundwater discharge	settling pits	none	not applicable
Decker Coal Co., Decker, Montana	Strip mining runoff, groundwater discharge	settling pits	Tongue River	Intermittent
Forsyth Ready Mix, Forsyth, Montana	Gravel-washing waste	settling pond	Yellowstone River	Intermittent
Miles City Meat Co., Miles City, Montana	Meat-packing associated liquid waste	2-cell lagoon	none	not applicable
Rahr Meat Service, Glendive, Montana	Meat-packing washwater waste	primary settling tank and 1-cell lagoon	Deer Creek	Intermittent

TABLE 10-22 (cont.)

INDUSTRY AND LOCATION	TYPE OF DISCHARGE	TREATMENT FACILITY	RECEIVING WATERS	DISCHARGE CHARACTERISTICS
Montana-Dakota Utilities Electrical Steam Generating Plant, Glendive, Montana	Thermal and ash pond discharge	ash pond	none	not applicable
Sidney Rendering Plant, Sidney, Montana	Rendering plant wash-water waste	1-cell lagoon	none	not applicable
Holly Sugar Co., Sidney, Montana	Beet-washing and process-water waste	primary clarifier, spray ponds, series of settling ponds	Yellowstone River	Intermittent
Montana-Dakota Utilities Electrical Steam Generating Plant, Sidney, Montana	Thermal and ash pond discharge	2-cell ash pond	Yellowstone River	Continuous

although this is possible in the future if these five industries expand. Characteristics of those industries that have discharges are shown below and also in Table 10-22.

Decker Coal Company, Decker, Montana

Average daily discharge	0.13 MGD
Total dissolved solids	0.88 tons/day
Total suspended solids	0.001 tons/day
Total iron	0.001 tons/day
Sodium	0.21 tons/day
pH	8.5
K25 (Specific Conductivity at 25°C)	1,840 umhos/cm at 25°C

Westmoreland Resources, Hardin, Montana

Average daily discharge	0.012 MGD
Total dissolved solids	0.03 tons/day
Total suspended solids	0.001 tons/day
Total iron	0.001 tons/day
Sodium	0.002 tons/day
pH	7.6

Holly Sugar Company, Sidney, Montana

Average daily discharge	1.3 MGD
BOD5	5.6 tons/day
Total suspended solids	0.42 tons/day
pH	6.8
Fecal coliform	10 million colonies/100 ml

Montana-Dakota Utilities, Sidney, Montana

Thermal Discharge

Average daily discharge	21.6 MGD
Temperature	37° C

Ash Pond Discharge

Average daily discharge	0.70 MGD
Total dissolved solids	2.46 tons/day
Total suspended solids	0.13 tons/day
Total iron	0.001 tons/day
Sodium	0.22 tons/day
pH	8.5
K25	910 umhos/cm at 25°C

The Rahr Meat Service discharge is to Deer Creek. Deer Creek is an intermittent stream, having flow only during spring runoff or in response to rain. The waste discharge has an average daily flow of about 0.01 million gallons per day and enters the creek about three miles up from its confluence with the Yellowstone River. The discharge normally either seeps into the Deer Creek stream bed or evaporates well above the confluence. Only when Deer Creek is flowing is any waste from the Rahr Meat Service discharge expected to reach the Yellowstone. Under these conditions, the pollutants are expected to be diluted.

In addition to municipal and industrial pollution sources in the study area, there are a number of sources of urban storm water runoff, irrigation return flows, and feedlot runoff. Similarly, natural erosion, sedimentation, and dissolution of soluble minerals significantly affect water quality, although it is difficult to locate and properly assess their impact. Many of these pollution sources are highly variable in time and in quality. No information on these wastes was gathered as part of this study.

3. Sampling Rationale

a. Site Selection

All major perennial streams in the study area were sampled during the study. In addition, a number of intermittent streams with large drainages were sampled. Extensive sampling was conducted on those streams in the immediate area of Colstrip and to the southeast, where the majority of the pollution effects from the development are expected to occur. Stream length, accessibility, and location of other waste quality stations were determining factors in locating sample sites. All major streams with high average flows were sampled at two or more sites. Wherever feasible, sampling sites were located above and below the confluences of major tributaries and points of changing water quality. Generally, one sampling station was allocated for smaller perennial streams on the outer edge of the study area.

Sixty-four major sampling sites were selected for the study area (see "Surface Water" Map and Table 2 in Appendix B2) in addition to 18 existing USGS water quality monitoring stations in the area (Table 4 in Appendix B2).

b. Sampling Frequency

Each major site was sampled at least twice prior to termination of field work in August 1974. At a minimum, samples were collected during winter low flows (base flow), high flow (spring runoff), and summer low flow (warm weather flow). It was felt that such sample periods would characterize water quality in the area. Some important stations located near Colstrip were sampled monthly or quarterly.

c. Water Quality Runs

To supplement the water quality analyses, water quality runs were also conducted on most perennial streams in the study area, particularly Armells Creek, Rosebud Creek, and the Yellowstone and Tongue Rivers. In this approach, a stream was sampled at a number of sites within a short period of time (one to two days). The number of samples taken was dependent upon stream length and site accessibility. Parameters tested were those readily measured in the field or amenable to transport and storage--specific conductance, pH, temperature, alkalinity, dissolved oxygen, and total suspended solids represent examples. Using this approach, a good understanding was developed of (1) downstream changes in water quality, and (2) the importance of various water and wastewater inputs along the stream.

d. Sample Collection

Water samples were collected in one-liter polyethylene bottles, dipped directly in the streams. Techniques for preservation and storage of the samples were in accordance with the 13th Edition of Standard Methods for the Examination of Water and Wastewaters (APHA et al. 1971); or where such techniques were not specified in Standard Methods, techniques were adopted from the recommended techniques of the Environmental Protection Agency. Bottles used to collect samples for metals analyses were acid-rinsed prior to sampling. The samples were then either filtered through a .45 micron filter, after which 5 ml of concentrated nitric acid per liter were added as a preservative, or samples not filtered had 5 ml of concentrated nitric acid added per liter. Concentrations of metals in the unfiltered sample were termed total recoverable metal concentrations. Standard biochemical oxygen demand (BOD) and dissolved oxygen (DO) bottles also were filled in the field, and the DO was "fixed" immediately. At some stations, samples were collected for bacteriological analysis in sterile bottles. Samples were transported in insulated sample containers to maintain appropriate storage temperatures.

Aquatic invertebrates were collected from stream substrates, such as rocks and logs, and by sweeping vegetation along the bank with a net.

e. Analytical Methods

The majority of the chemical analyses were completed in the Water Quality Bureau's Helena laboratory. Tests conducted in this laboratory and analytical techniques are outlined in Table 10-23.

Those parameters for which samples could not be stored were analyzed on site or in the branch laboratory of the Water Quality Bureau in Billings. Analytical techniques and tests used in the field and in the Billings laboratory are summarized in Table 10-23.

Bacterial analyses generally were done by the Millipore filter technique (Millipore Corporation 1972), which also is described in Standard Methods (APHA et al. 1971). Fecal coliform counts were done routinely; total coliform and fecal strep counts were also done on some of the samples. Serial dilutions generally were not applied to stream samples, since low fecal coliform counts were typically obtained. Municipal wastewater effluents, however, were appropriately diluted. Rapid biological assessments were made on certain streams in the study area.

f. Flow Determinations

Generally, stream flows were measured at each sampling site each time the station was sampled, to provide information on relative importance to a stream of its discharge and its total pollution load. Seasonal and periodic fluctuations in stream discharges were ascertained in this manner. In a few instances during the sampling programs, stream flows were not obtained due to problems in wading the stream or time constraints. At sampling sites that had USGS gaging stations, flow was obtained from the USGS records. In instances where gaging stations had been discontinued, nearby gaging station records were obtained, and flows for the ungaged section were estimated by comparison with the gaged section. Flows in ungaged streams were measured using a Gurley Pygmy Meter. The stream was measured at intervals along a transect across the stream and water velocity was obtained utilizing the six-tenth depth method which measures velocity at a point six-tenths of the total stream depth below the surface. In the larger ungaged streams, a price-type Gurley Meter was used. On occasion, streams were measured utilizing surface water floats and timing the floating material for a measured distance. Flows and flow-measuring techniques were recorded on field data sheets and

TABLE 10-23

ANALYTICAL METHODS

PARAMETER	REFERENCED[1]	METHOD
1. Total Alkalinity	SM	Potentiometric Titration with 0.02N H_2SO_4
2. Arsenic	SM	Silver Diethyldiothio-carbomate
3. Beryllium	SM	Atomic Absorption
4. Cadmium	SM	Atomic Absorption
5. Calcium	SM	(A) EDTA Titration
	SM	(B) Atomic Absorption
6. Chloride	SM	Mercuric Nitrate Titration
7. Chromium	SM	Atomic Absorption
8. Cobalt	SM	Atomic Absorption
9. Copper	SM	Atomic Absorption
10. Dissolved Oxygen	EPA	Modified Winkler
11. Fluoride	EPA	(A) Automated Complexone Method
	Orion	(B) Specific Ion Electrode
12. Hardness	SM	EDTA Titration
13. Iron	USGS	(A) Ferron-Orthophenanthroline
	SM	(B) Atomic Absorption
14. Lead	SM	Atomic Abosrption
15. Lithium	SM	Atomic Absorption
16. Magnesium	SM	Atomic Absorption
17. Manganese	SM	Atomic Absorption
18. Mercury	SM	Atomic Absorption
19. Nitrate-Nitrogen	EPA	Automated Hydrazine Reduction, Diazotization
20. Orthophosphate	EPA	Automated Molybdate-Antimonyl Tartrate Method
21. Potassium	SM	pH Meter
22. Potassium	SM	Atomic Absorption
23. Selenium	SM	Atomic Absorption
24. Settleable Solids	SM	Imhoff Cone
25. Sodium	SM	Atomic Absorption
26. Specific Conductance	SM	Wheatstone Bridge
27. Sulfate	USGS	Thorin Titration

TABLE 10-23 (cont.)

PARAMETER	REFERENCED[1]	METHOD
28. Suspended Solids	SM	Filtration, Evaporation at 105° C, Gravimetric
29. Turbidity	SM	Nephelometric
30. Vandaium	SM	Atomic Absorption
31. Zinc	SM	Atomic Absorption
32. Coliform, Fecal	SM	Membrane Filter
33. Coliform, Total	SM	Membrane Filter
34. Strep, Fecal	SM	Membrane Filter

[1] SM - APHA et al. 1971

EPA - U.S. Environmental Protection Agency

USGS- USGS 1970

Orion- Procedures recommended by equipment manufacturers.

subsequently placed into computer storage along with the chemical data.

4. Sampling Results

Results from the analysis of over 270 samples collected at 95 sites during this study are summarized below by drainage system. Raw data from the sampling and analysis, and comprehensive tabulations of baseline water quality data in the study area, are available from the Water Quality Bureau and Energy Planning Division.

Data were collected during high flow (spring runoff), low flow (winter), and warm-weather low flows (summer). This selection was considered adequate to define the range in water quality in the streams.

Common constituents and toxic metals are designated by chemical symbols and concentrations are given in milligrams per liter. The following abbreviations also have been used:

F.C.	Fecal Coliform
F.S.	Fecal Strep
T.C.	Total Coliform
T.A.	Total Alkalinity
T.H.	Total Hardness
CaH.	Calcium Hardness
MgH.	Magnesium Hardness
CDS.	Calculated Dissolved Solids
TSS.	Total Suspended Solids

The units used are as follows:

Flow	cubic feet per second (cfs) (an "E" denotes an estimated flow)
Temperature	degrees Centigrade
K	Micromhos per cm at 25° C
Turbidity	JTU (Jackson Turbidity Units)
Bacteria	Counts per 100 ml of sample
Load (BOD)	Tons or pounds per day, as designated.

Total alkalinity, total hardness, calcium hardness, and magnesium hardness are all expressed in milligrams per liter as calcium carbonate ($CaCO_3$). Total alkalinity measured during water quality runs is expressed in milli-equivalents per liter (meq/l). Individual tables are self descriptive in terms of the quality of water at any given site.

a. Summary of Existing Surface Water Quality

i. Little Bighorn River

The USGS maintains two water quality stations on the Little Bighorn River--near Wyola and near Hardin. The USGS also had a station at Crow Agency. The Water Quality Bureau established stations on major tributaries to the Little Bighorn River: Pass Creek, Owl Creek, and Lodge Grass Creek. The sampling sites on these tributaries were established near their respective confluences with the Little Bighorn River. An additional set of samples was collected from three of the forks of Owl Creek's upper drainage. Several minor tributaries, including Spring, Grey, Blanket, and Reno Creeks, were also sampled near their confluence with the Little Bighorn River.

Table 10-24 shows typical quality of surface waters in the Little Bighorn drainage. Specific conductances and dissolved solids concentrations are slightly higher for major tributaries and considerably higher for minor tributaries than for the mainstem river. This indicates concentrations of dissolved constitutents are higher in tributaries. This is particularly noticeable for sodium and sulfate. Pass Creek and Owl Creek are both significant contributors to suspended sediment loads in the Little Bighorn River during periods of high flow.

There is a general increase in concentrations of dissolved constituents and sediment for the Little Bighorn River mainstem from state line to Hardin. Of the dissolved constituents, sodium and sulfate show the largest increases. The highest concentrations of sediment in the Little Bighorn near Hardin occur in early spring rather than during the peak runoff period. This suggests that the relatively high flows created by early season runoff from prairie drainages produce the higher concentrations of suspended sediment.

ii. Bighorn River

The USGS maintained water quality stations on the Bighorn near St. Xavier, (Yellowtail Reservoir discharge) Hardin, and at Bighorn. The Water Quality Bureau collected occasional samples at the USGS site at Hardin and at the USGS site at Bighorn. The major tributary to the Bighorn River is the Little Bighorn River. Other tributaries of importance to water quality in the Bighorn River are Soap, Rotten Grass, Beauvais, and Tullock Creeks. The USGS maintains a sampling station on Beauvais Creek about 14 miles above its confluence with the Bighorn River. The Water Quality Bureau established sampling sites on the three remaining streams at their respective confluences with the Bighorn River. A site was also established on the upper reach of Tullock Creek near Hardin.

Table 10-25 shows typical chemical analysis of surface waters in the Bighorn River drainage. Only data on the Bighorn River mainstem after regulation by Yellowtail Reservoir have been considered. The data for any one station on the Bighorn River show very little variation in concentration with changes in flow. This is probably due to the fact that the variation in flow is small and water being discharged from the reservoir is taken not from the surface but from approximately 150 feet below the surface. The Bighorn River has a relatively high concentration of sulfate as compared to the other major rivers in the region. There is little change in the concentration of dissolved constituents from the station near St. Xavier to the station at Bighorn. This indicates that streams tributary to the Bighorn River have a minor effect on water quality of the Bighorn, although there is an apparent increase in the concentration of suspended sediment between these two stations which may be due to the inflow from tributary streams.

Early spring runoff from the prairie portion

TABLE 10-24

Typical chemical analysis of surface waters in the Little Bighorn River sub-basin

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/1)	Dissolved Oxygen DO (mg/1)	Biological Oxygen Demand BOD (mg/1)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/1)	Magnesium Mg (mg/1)	Sodium Na (mg/1)	Potassium K (mg/1)	Total Hardness CaCO$_3$ (mg/1)	Bicarbonate HCO$_3$ (mg/1)	Carbonate CO$_3$ (mg/1)	Alkalinity CaCO$_3$ (mg/1)	Sulfate SO$_4$ (mg/1)	Chloride Cl (mg/1)	Fluoride F (mg/1)	Nitrate NO$_3$ (mg/1)	Phosphate PO$_4$ (mg/1)	Iron Fe (mg/1)	Manganese Mn (mg/1)	Zinc Zn (mg/1)	Copper Cu (mg/1)	Cadium Cd (mg/1)	Lead Pb (mg/1)	Arsenic As (mg/1)	Mercury Hg (mg/1)	Chromium Cr (mg/1)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/1)
Little Bighorn River Mainstem																																			
near Wyola	07S 35E 35CC	6/10/70	1820	0.5	8.0	360	195				48	14	6.2	1.6		200	0		19	0.6	.2			.050											
	07S 35E 35CC	6/2/71	850	11.0	8.0	389	231				51	17	7.8	0.7		204	0		46	0.8	.2			.030											
	07S 35E 35CC	7/1/72	860	14.5	7.8	348	201				47	14	5.8	[illegible].8		184	0		36	0.3	.2			.030											
	07S 35E 35CC	12/4/69	128	2.0	7.7	596	350				66	27	20	1.1		252	0		103	1.2	.1			.017											
	07S 35E 35CC	12/2/70	153		8.3	602	377				70	28	23	1.5		270	0		110	1.2	.2			.040											
	07S 35E 35CC	12/2/71	92	0.0	7.9	639	398				76	30	22	1.[illegible]		264	0		130	1.0	.1			.000											
	07S 35E 35CC	9/16/70	209		7.9	673	375				70	24	25	1.[illegible]		268	0		111	1.2	.2			.064											
	07S 35E 35CC	9/1/71	115	19.0	8.1	649	404				70	31	27	2.2		288	0		120	1.7	.7			.030											
near Hardin	01S 34E 19AA	6/10/70	2060	17.0	8.0	474	290				67	30	36	3.0		266	0		154	2.3	.2			.013											
	01S 34E 19AA	6/2/71	1080	13.5	7.9	550	332				52	24	27	1.7		240	0		100	1.5	.2			.030											
	01S 34E 19AA	6/3/72	1170	20.5	7.4	434	256				48	19	13	1.5		212	0		61	1.9	.1			.030											
	01S 34E 19AA	12/4/69	154	1.5	7.8	748	486				64	38	49	2.5		285	0		182	2.6	.2			.160											
	01S 34E 19AA	12/2/70	320		8.3	797	509				74	36	48	2.6		307	0		190	2.6	.3			.000											
	01S 34E 19AA	12/3/71	124	1.5	8.0	856	561				81	41	58	2.3		298	0		220	4.4	.2			.010											
	01S 34E 19AA	9/15/70	292		8.1	660	432				67	30	36	3.[illegible]		266	0		154	2.3	.3			.013											
	01S 34E 19AA	9/14/71	151	17.0	8.1	694	452				57	35	42	2.5		258	0		180	1.5	.2			.020											
	01S 34E 19AA	9/5/72	148	19.0	8.1	656	411				57	32	38	2.1		229	0		160	3.2	.2			.200											
at MT/WY state line	09S 33E 36CB	3/21/74	65	0.0	8.30	350	322	12.3		0	46	15.5	9.4	[illegible]	180	209	12	191	22	0.2	.12	0.0	.05	.13		<.01	<.01	<.01	<.01				0.3	1	0
	09S 33E 36CB	5/1/74	218	5.4	8.32	314	267	10.9	1.5	20	44	14.[illegible]	1.3		170	189	4	162	12.5	0.3		0.52	.06	.03	<.01	<.01	<.01	<.001			<.001		0.0	6	9.0
near Wyola	07S 35E 35CC	12/20/73	110	1.0	8.52		601	13.4	2.5	3														.13		<.01	<.01	<.01	<.01					2	
	07S 35E 35CC	2/15/74	121	4.0	8.01	653	526	12.3	3.2	0	75	30	24		309	259	0	212	138	.04		0.68	0.0	.30	0.06	<.01	<.01	<.01			<.001		0.6	10	22.5
	07S 35E 35CC	4/3/74	141	5.0	8.37	692	566	12.5	2.8	9	63	38	40		313	247	6	212	172	0.2	.19	0.0	0.03	.29	0.05	<.01	<.01	<.01		<.01	<.001		1.0	8	18.0
	07S 35E 35CC	5/14/74	461	8.8	8.31	482	385	11.5	2.9	12	63	19	12		234	223	5	190	63	0.2		0.13	0.04	.70	0.05	0.01	<.01	<.001			<.001	<.01	0.3	14	46.5
near Hardin	01S 34E 19AA	2/15/74	265	0.0	8.04	1450	737	12.1	2.3	70	77	42	64		366	299	0	246	250	2.4		1.5	0.56										1.5	23	56.5
	01S 34E 19AA	3/6/74	256	3.1	8.20	984	790	12.5	3.5	25	77	46	78		381	296	4	249	285	3.0		0.42	0.82	2.5		0.02	0.01	<.01	<.01	<.01	<.001	0.01	1.7	51	122
	01S 34E 19AA	5/14/74	482	11.8	8.31	602	492	10.7	2.5	28	61	29	28		271	245	5	209	122	2.0		0.07	0.05	1.8	0.08	0.02	<.01	<.001		<.001	<.001	<.01	0.7	41	123
(middle)		5/14/74	472E	11.2	8.26	562	455	10.8	2.5	51	61	27	23		261	237	7	206	100	1.0		0.08	0.05	1.4	0.06	0.01	<.01	<.001			<.001		0.6	24	86.7
Tributaries																																			
Spring Creek	09S 34E 30ABD	4/3/74	3.0	8.0	7.65	837	692	12.4	1.2	0	117	40	13		458	253	0	208	268	0.2	.14	0.24	0.03	.03	<.01	<.01	<.01	<.01		<.01	<.001		0.3	0	4.0
Pass Creek	08S 35E 22ACD	3/21/74	20.8	0.0	8.20	1023	856			4	83	37	85	27	359	298	0	244	325	1.0	.18	0.[illegible]	<.03	1.8	0.08	0.01	<.01	<.001		<.01			2.0	30	58.0
	08S 35E 22ACD	5/1/74	117	10.0	8.33	601	494	9.70	1.5	580	67	27	24		280	278	4	234	92	1.4		0.60	0.07	2.5	0.14	0.02	<.01	<.001			<.001		0.6	53	226
Upper Owl Creek	07S 36E 34AA	5/15/74	15.0	10.5	8.25	769	648	10.0	2.1	171	58	41	53		313	406	0	333	87	2.0		0.[illegible]	0.05	.12	0.09	0.01	<.01	<.001			<.001		1.3	34	87
East Owl Creek	07S 36E 11BC	5/15/74	17.7	9.0	8.23	970	803	10.6	2.5	600	86	71	20		507	423	0	347	200	2.0		0.77	0.12	2.1	0.15	0.02	<.01	<.001			<.001		0.4	53	146
Sioux Pass Creek	07S 36E 03BC	5/15/74	6.5	9.3	8.21	992	829	12.2	2.3	18	68	76	41		484	429	7	364	204	3.0		0.0	<.03	.18	0.05	0.01	<.01	<.001			<.001		0.8	3	8.6
Owl Creek	06S 36E 30AB	2/15/74	17.6	0.0	8.13	1156	791	11.5	2.4	30	71	53	60		394	451	[illegible]	370	150	2.4		3.3	0.23	.57		<.01	<.01	<.01	<.01		<.001		1.3	16	33.6
	06S 36E 30AB	5/1/74	35.3	10.2	8.24	906	791	9.3	1.7	30	67	57	59		400	436	0	357	168	3.6		0.50	0.08	<.01	0.04	0.01	<.01	<.001			<.001	<.01	1.3	60	182
Grey Blanket Creek	06S 36E 19AA	5/15/74	5.0	9.7	8.28	1036	861	11.5	2.2	53	70	76	49		489	418	15	367	230	3.0		0.27	<.03	.20	0.03	<.01	<.01	<.001			<.001		1.0	5	14.2
Lodge Grass Creek	06S 35E 13DA	11/20/73	48.5	0.0	7.51	843	659	12.9	2.6	6	92	38	33		385	256	0	210	238	1.2		0.11	0.52	.41		<.01	<.01	<.01	<.01	<.01			0.7	9	
	06S 35E 13DA	2/15/74	55.4	0.0	7.97	909	713	12.3	1.1	30	100	38	48		407	217	5	186	303	1.6		0.31	0.01	.51	0.04	<.01	<.01	<.01			0.001		1.0	13	28.5
	06S 35E 13DA	4/3/74	18.0	5.8	8.22	1332	1108	12.0	2.9	0	110	63	113		534	320	0	262	497	4.8	.21	0.0	<.03	.23	0.05	<.01	<.01	<.01		<.01	0.001		2.1	3	7.0
	06S 35E 13DA	5/15/74	6.8	11.9	8.11	1588	1297	10.2	1.7	10	119	75	144		609	338	6	287	607	6.8		0.[illegible]	<.03	.25	0.05	<.01	<.01	<.001		<.001	<.001	<.01	2.5	2	6.0
Reno Creek	04S 36E 11AC	5/14/74	1.3	13.3	8.48	1414	1215	12.6	3.5	55	45	60	208		360	637	26	566	238	0.2		0.0	0.06	.41	0.05	0.01	<.01	<.001			<.001		4.8	7	20.0

* See Appendix B2

TABLE 10-25

Typical chemical analysis of surface waters in the Bighorn River sub-basin.

Sampling Site Designation	Sampling Site Location*	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25°	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadmium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Bighorn River Mainstem																																			
near St. Xavier	06S 31E 16BA	6/2/70	3830	5.5	7.9	976	672				88	30	88	4.1		241	0		322	11	.5	.05		.109											
	06S 31E 16BA	6/4/71	8190	9.0	7.9	930	652				80	28	89	3.7		220	0		320	12	.4			.020											
	06S 31E 16BA	6/8/72	6200	8.0	6.6	818	534				69	23	72	3.6		191	0		250	11	.6			.020											
	06S 31E 16BA	12/9/69	3240	7.0	8.1	978	670				80	29	101	4.5		217	0		325	12	.5			.036											
	06S 31E 16BA	12/1/70	2760		7.8	812	563				73	23	79	3.8		192	0		270	12	.5			.030											
	06S 31E 16BA	12/8/71	4460	5.0	7.9	835	519				66	22	73	3.4		185	0		240	10	.3			.000											
	06S 31E 16BA	9/1/70	1700		7.7	664	445				62	20	59	3.5		170	0		200	6.4	.3			.006											
	06S 31E 16BA	9/10/71	2570	17.0	7.7	517	334				43	14	43	2.5		146	0		140	6.2	.6			.010											
	06S 31E 16BA	9/6/72	3170	15.5	7.7	611	394				54	17	49	2.5		149	0		180	6.4	.4			.030											
near Hardin	01S 33E 24AD	3/2/70	4600																333	13															
	01S 33E 24AD	6/2/71	8000						1.2		65	28							320	11															
	01S 33E 24AD	6/12/72	5640						1.5		69	24							250	10															
	01S 33E 24AD	4/6/70	530																440	13															
	01S 33E 24AD	10/2/70	1600						3.3		79	27							310	12															
	01S 33E 24AD	2/2/72	4000						1.4		72	25							260	11															
	01S 33E 24AD	8/20/70	1900								66	26								10															
	01S 33E 24AD	9/14/71	2400						1.8		47	15							160	6.2															
	01S 33E 24AD	8/21/72	2860						2.0		57	17	51						190	7.3	.4														
at Bighorn	05N 34E 33AA	3/5/69	5030		7.9	914					80	27	83	4.2		219	0		295	11	.5	1.9		.070											
	05N 34E 33AA	6/15/71	9160	16.0	8.0	926	590				75	28	90	3.4		213	0		270	9.8															
	05N 34E 33AA	4/14/72	7170	5.0	8.1	871	573				72	25	76	4.2		207	0		270	12	.4			.010											
	05N 34E 33AA	12/5/68	4230		8.0	900					73	26	84	3.6		212	0		288	13	.4	1.6		.040											
	05N 34E 33AA	1/25/71	3930	1.0	8.0	740	530				70	24	69	3.9		191	0		250	8.1	.4			.120											
	05N 34E 33AA	12/6/71	3660	2.0	8.2	859	541				70	25	76	3.5		197	0		250	10	.4			.020											
	05N 34E 33AA	9/8/69	3750		7.9	866					70	24	84	4.1		188	0		284	9.4	.4	2.0		.070											
	05N 34E 33AA	9/8/71	3030	18.0	7.6	609	402				50	18	52	3.0		160	0		180	6.9	.8			.020											
	05N 34E 33AA	8/7/72	3230	21.0	7.9	673	433				57	20	58	3.0		163	0		200	6.2	.3			.030											
near Hardin	01S 34E 19BE	7/4/73	6000E	13.0		838	622	9.1	1.7	75	58	26	83		251	202	0	166	240	11.8	.33	.28	<.01	.25			<.01	<.01	<.01	<.01			2.3	8	
	02S 33E 21BC	2/15/74	4230	13.0	8.11	914	701	12.0	1.1	10	75	29	83		309	191	0	167	305	10.6		1.0	0.0	.19	.07	0.01	<.01	<.01	<.01		0.007		2.1	2	10.5
	01S 34E 19BA	3/6/74	4820	2.8	8.16	930	708	12.6	2.5	12	78	28	82		311	205	0	168	303	10.5		.93	0.11	.24		<.01	<.01	<.01	<.01	<.01	<.001	<.01	2.0	4	14.8
	02S 33E 21BC	5/16/74	4090	4.5	8.08	982	750	12.4	2.4	26	87	33	83		355	204	12	187	317	13.2		.22	<.03	.16	.01	<.01	<.01	<.001		<.001	<.001	<.01	1.9	4	8.0
at Bighorn	05N 34E 33AA	7/11/73	3700E	18.5		912	605	7.8	3.6	80	60	24	76		249	195	0	160	239	10.2	.31	.22	0.04	.07			0.04	<.01	<.01	<.01			2.1	11	
	05N 34E 33BC	1/22/74	3480	0.5	7.81	860	639	12.5	5.1	170	82	16	75		271	191	0	157	264	9.0		1.4	0.20	1.1	.04	<.01	<.01	<.01			0.003		2.0	30	113
	05N 34E 34BC	2/16/74	4640	4.0	8.13	982	749	12.0	2.5	70	74	32	97		314	222	7	194	307	9.0		1.1	0.01	.58	.07	0.01	0.01	<.01			0.007		2.4	18	40.0
	05N 34E 34BC	4/25/74	6660	9.9	8.30	994	768	10.5	1.6	10	77	36	90		340	240	0	197	314	11.2		.44	0.04	1.0	.05	0.01	<.01	<.001			<.001		2.1	23	65.0
	05N 34E 34BC	5/16/74	5060	7.9	8.42	954	710	11.7	2.0	25	83	30	79		332	212	7	186	285	13.0		.26	0.04	.75	.03	<.01	<.01	<.001		<.001	<.001	<.01	1.9	16	39.2
Tributaries																																			
Crooked Creek	09S 27E 34AA	3/20/74	0.5	6.5		2300	2162				483	84	21	18	1552	148	0	121	1392	15.0	1.2	0.0											0.2		
	09S 27E 34AA	5/30/74	24.5	9.8	8.30	433	361				59	19.5	3.9		228	234	4	198	39	0.7		.27	0.04	4.5	.25	0.03	<.01	<.001		<.001			0.1		
Soap Creek	05S 32E 29AB	12/20/73	11.6	0.0	8.23	1500		13.2	3.2	4													0.18			0.01	<.01	<.01	<.01					8	22.8
	05S 32E 29AB	3/31/74	15.0	3.0	8.19	1021	822	10.5	1.6		117	42	56		467	257	0	224	334	7.0	.54	.13	0.11	2.5	.13	0.01	<.01			<.01	<.001		1.1	51	178
	05S 32E 29AB	5/1/74	138	15.1	8.31	849	690	9.9	2.5	610	84	44	43		391	285	5	241	227	2.3		.18	0.12	3.9	.22	0.02	<.01	<.001			<.001		0.9	80	341
Rotten Grass Creek	05S 33E 17DA	11/19/73		0.5	7.75	2020	1227	12.5	3.1	20	160	66	97		672	269	0	220	628	6.0		.27	0.45	.74		<.01	<.01	<.01	<.01	<.01			1.6	19	
	05S 33E 17DA	12/20/73	18.0	0.0	8.42	1642		13.1	4.1	1980														.35		<.01	<.01	<.01	<.01					10	25.0
	05S 33E 17DA	2/15/74	22.3	0.3	7.87	1536	1318	12.2	1.8	20	150	83	106		715	314	0	257	656	6.0		3.5	0.73	2.3		0.02	<.01	<.01	<.01		<.001		1.7	52	138
	05S 33E 17DA	4/3/74	17.5	5.0	8.27	1533	1247	10.9	2.9	84	134	67	124		610	300	0	246	614	7.0	.38	.66	0.11	3.6	.19	0.03	<.01	<.01		<.01	<.001		2.2	77	228
	05S 33E 17DA	5/1/74	112	11.6	8.19	843	726	10.3	2.5	920	83	38	65		362	254	0	208	283	3.4		.54	0.08	9.5	.50	0.07	0.01	<.001			<.001		1.5	90	996
Tullock Creek E of Hardin	01N 35E 36DD	1/31/74		0.0		1226	968	8.0	4.9	5	34	39	185		245	382	0	313	323	4.0		1.4	0.30	1.0	.08	0.01	<.01	<.01	<.01	<.01		0.01	5.1	35	
	01N 35E 36DD	3/6/74	24.2	0.0	8.05	1184	943	11.6	4.9	0	32	43	170		256	421	4	351	267	4.1		2.3	0.11	2.4		0.01	0.01		<.01	<.01	<.001	<.01	4.6	44	118
	01N 35E 36DD	6/11/74	25.5	17.2	8.48	1270	1027	8.5	4.4		41	62	184		359	454	51	469	230	4.5		.09	0.06	.78	.04	0.01	0.01	<.001			<.001			14	28.0
Tullock Creek near Bighorn	04N 34E 02AC	1/31/74	28	0.0	7.95	942	716	8.9	3.8	11	33	28	132		197	258	0	212					0.30	1.4	.05	0.01	0.01	<.01	<.01	<.01		<.01	4.1	31	50.0
	04N 34E 02AC	2/16/74	30.1	0.2	7.91	911	1005	10.7	3.4	0	37	37	200		245	412	5	346	312	0.4		1.5	0.14	1.4	.07	0.01	<.01	<.01			<.001		5.6	48	88.0
	04N 34E 02AC	4/17/74	7.8	11.5	8.41	1990	1618	9.8	3.1	34	57	56	338		374	528	16	459	612	10.0	.46	.04	0.03	1.6	.15	0.01	0.01	<.001		0.007			7.6	37	76.0
	04N 34E 02AC	6/11/74	36.8	17.1	8.31	2422	1971	7.7	5.8		77	52	450		405	572	72	589	735	13.5		.26	0.09	1.4	.53	0.02	<.01	<.001		0.001	<.001	0.02	9.7	245	882
Beauvais Creek near St. Xavier	04S 30E 15	5/5/70	125	20.0	8.1	930	655		1.6		84	23	93	6.5		201	0		330	5.4	.4		0.18	.149	.03	.013	0	0.024	0	0		0			1500
	04S 30E 15	5/3/71	50	19.5	8.3	1010	659	9.8	2.8		140	35	13	3.1		242			330	2.7	0.0			.040	.07	.010	.006	0	0			0			321
	04S 30E 15	3/16/72	68	10.5	8.5	782	533	9.8	1.6		90	24	51	3.3		222	0		240	2.9	.[illegible]			.020	.08	.030	.020	0.003	.014			0			308
	05S 30E 15	2/11/69	3.6	0.0	8.1	1500		11.2	3.3		230	47	66	3.2		218	0		712	3.4	.5	1.0	0.21	.270											
	05S 30E 15	12/11/69	1.9	0.0	8.2	1900	1620	11.8	1.1		330	68	67	3.2		303	0		985	3.2	.5		0.02	.032											138
	05S 30E 15	12/9/71	1.5	0.0	7.4	1530	1190	12.4	0.9		240	54	45	2.6		263	0		700	2.6	.5			0	.25										300
	05S 30E 15	8/4/69	7.1	22	8.2	1300		7.2	1.8		198	46	37	3.4		192	0		600	3.2	.5	0.0	0.07	.010											
	05S 30E 15	8/18/70	5.0	19.5	7.8	1370	1140	7.8	0.7		250	50	24	3.2		162	0		720	2.4	.2		0.46	.020	.01										32
	05S 30E 15	8/21/72	7.9	15.5	8.1	1460	1110	8.2	1.7		230	46	42	4.9		206	0		670	2.1	.[illegible]			.110	.02										500

* See Appendix B2

of the drainage causes a temporary increase in sediment concentration in the Bighorn River at Bighorn. However, maximum mean monthly sediment concentrations in the Bighorn River apparently occur in May and June, when tributary streams with mountainous drainage areas have their peak runoff.

Rotten Grass Creek, Beauvais Creek, and Tullock Creek have substantially higher specific conductivities than does the Bighorn River. This indicates higher concentrations of dissolved constituents in the tributaries. In general, concentrations of each common ion in tributary streams are higher than in the Bighorn River. The concentration of common ions in Soap Creek and in the Little Bighorn River is lower than in the Bighorn River. Suspended sediment concentrations are significant during runoff periods for all tributaries of the Bighorn.

iii. Rosebud Creek

The Water Quality Bureau established six sampling sites on Rosebud Creek to obtain data for this investigation. These are (1) south of Kirby, (2) at Busby, (3) south of Colstrip, (4) east of Colstrip, (5) south of Rosebud, and (6) near Rosebud. Tributaries to Rosebud Creek sampled by the Water Quality Bureau are Indian Creek, Davis Creek, Muddy Creek, and Lame Deer Creek. Only one sampling site was established on each tributary stream near its confluence with Rosebud Creek (see sites plotted on the "Surface Water Map).

Table 10-26 shows typical chemical analysis of surface waters in the Rosebud Creek sub-basin. Increases in concentrations of common ions in waste as it moves downstream along Rosebud Creek are not large for any particular ion. There is a general increase in sodium, magnesium, sulfate, and chloride. One unusual feature of many samples collected on Rosebud Creek is the high ratio of magnesium to calcium. This also is true for samples collected on tributaries with the exception of Indian Creek in the upper part of the Rosebud drainage, the only tributary sampled having a water quality better than Rosebud Creek. The remaining tributaries sampled have specific conductances significantly higher than those for Rosebud Creek. The associated higher concentrations of common ions are magnesium, sodium, bicarbonate, sulfate, and chloride. There is a definite increase in sediment concentrations from the upper station on Rosebud Creek to the lower station.

iv. Tongue River

The USGS maintains water quality stations on the Tongue River at the state line and at Miles City. The Water Quality Bureau established sampling sites on the Tongue River upstream from the Montana-Wyoming station line above the reservoir, on the Tongue River Reservoir, below the reservoir discharge near Birney, and at Ashland. Several samples also were collected by the Water Quality Bureau at the USGS stations.

The USGS maintains water quality stations on Hanging Woman Creek and Otter Creek near their confluences with the Tongue River. These stations were established only recently and no data have been published for the sites. As a result, the Water Quality Bureau established sampling stations on both of these creeks at the current USGS sites in addition to upstream stations on each

TABLE 10-26

Typical chemical analysis of water in the Rosebud Creek sub-basin--
Rosebud Creek and tributaries.

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance (umhos/cm @ 25° C)	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Flouride F (Mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Rosebud Creek Mainstem																																			
S of Kirby	06S 39E 29BA	1/17/74	5.7	0.0	8.31	762	613	11.3	4.3	41	88	41	11		390	384	0	315	85	1.5	.50	0.94	0.21	0.47		<.01	<.01	<.01	<.01	0.01			0.2	10	9.0
	06S 39E 29BA	2/28/74	11.2	0.0	8.09	880	749	12.0	3.2	3000	72	68	23		459	435	0	357	150	1.2		0.23	0.11	0.53		0.01	<.01	<.01	<.01	<.01	<.001	<.01	0.5	9	18.0
	06S 39E 29BA	4/17/74	27.0	11.0	8.48			13.3		5																								11	24.0
	06S 39E 29BA	4/30/74	22.7	14.0	8.33	760	641	9.2	1.7	30	72	54	17		403	367	11	319	118	1.6		0.04	0.03	0.44	0.08	0.01	<.01	<.001			<.001	<.01	0.4	10	28.0
at Busby	04S 39E 06AB	7/4/73		18.0		785	672	7.9	3.1	170	58	57	31		381	431	4	365	90	0.3	.51	0.78	0.02				<.01	<.01	<.01	<.01			0.7	51	
	04S 39E 06AB	1/17/74	75.6	0.0	7.63	485	363	11.6	11.4	480	47	194	18		197	213	0	175	61	2.5	.18	1.1	0.53	0.30		<.01	<.01	<.01	<.01	<.01			0.6	11	25.9
	04S 39E 06AB	2/28/74	18.0	0.0	8.18	997	[illegible]	12.9	4.0	2	69	73	46		473	472	0	387	189	1.5		0.22	0.07	0.35		0.01	0.01	<.01	<.01	<.01	<.001	<.01	0.9	[illegible]	12.0
	04S 39E 06AB	4/30/74	63.8	11.8	8.34	805	705	9.8	3.0	30	66	60	28		412	429	0	352	118	3.1		0.12	0.09	3.2	0.21	0.01	<.01	<.001			<.001		0.6	78	254
S of Colstrip	01S 42E 08DB	12/13/73	20.5	2.2	8.31	1320		12.8	2.9	2														0.32		0.01	<.01	<.01	<.01					10	20.8
	01S 42E 08DB	1/17/74		0.0	7.92	1152	937	11.7	9.3	100	104	62	67		515	372	0	305	327	3.0	.34	1.3	0.26	1.0		<.01	<.01	<.01	<.01	0.01			1.3	8	8.0
	01S 42E 08DB	1/24/74	100.2	0.0	7.73	699	523	11.8	8.1	20	58	34	31		286	254	0	209	140	3.5		1.5	0.29	0.56	0.02	<.01	<.01	<.01			0.001		0.8	12	25.0
	01S 42E 08DB	3/1/74	24.5	0.0	8.21	1298	1081	13.0	3.8	21	80	91	84		574	486	0	398	337	2.8		0.13	0.05	0.39		0.01	0.01	<.01	<.01	<.01	<.001		1.5	8	13.5
	01S 42E 08DB	4/30/74	81.9	13.3	8.36	972	815	9.2	3.1	20	69	74	49		476	400	17	356	202	3.4		0.16	0.13	8.2	0.33	0.04	0.01	<.001			<.001	0.02	1.0	180	550
E of Colstrip	03N 43E 05DC	3/1/74	27.6	0.0	8.28	1257	1038	12.6	4.1	4	75	88	88		549	431	4	359	350	2.9		0.31	0.06	0.78		0.01	0.01	<.01	<.01	<.01	<.001		1.6	17	28.0
	03N 43E 05DC	4/30/74	70.2	13.5	8.35	1016	834	9.2	3.1	40	68	74	51		474	400	14	352	222	3.6		0.36	0.13	8.8	0.38	0.06	0.01	<.001			<.001		1.0	190	[illegible]
S of Rosebud	05N 42E 08DC	12/14/73	36.9	1.0	8.32	1620		12.8	2.7	16														0.34		<.01	<.01	<.01	0.01					[illegible]	[illegible]
	05N 42E 08DC	3/1/74	30.6	0.9	8.00	1191	996	12.5	4.3	3	66	81	88		499	417	0	342	338	4.8		0.58	0.08	1.9		0.02	0.01	.01	<.01	<.01	<.001		1.7	[illegible]	112
	05N 42E 08DC	4/30/74	77.2	12.8	8.29	1036	885	9.8	3.2	90	66	77	60		484	419	14	368	243	4.6		0.26	0.13	7.8	0.45	0.05	0.01	<.001			<.001		1.2	210	564
	05N 42E 08DC	6/20/74	58.8	22.4	8.42	1047	870	8.3			66	75	60		472	420	4	351	241	4.0		0.38	0.12	6.8	0.39	0.05	0.01	<.001		<.001	<.001	0.01	1.2	[illegible]	[illegible]
near Rosebud	06N 42E 16DC	10/24/73	4E			1580	1322				135	72	138		634	504	9	429	453	8.0	.56	1.5	0.29										2.4	43	
	06N 42E 16DC	1/21/74	180.4	0.0	7.68	584	419	12.1	11.6	240	51	13.3	47		183	163	0	134	137	5.8		0.63	0.49	2.5	0.05	<.01	0.01	<.01		<.01			1.5	82	200
	06N 42E 16DC	3/1/74	36.5	1.1	7.90	1162	943	12.6	4.6	150	63	76	92		468	397	0	326	310	4.2		0.47	0.83	2.5		0.01	0.01	<.01	<.01	<.01	<.001	0.01	1.9	52	130
	06N 42E 16DC	4/17/74	74.0	11.0	8.42	1239	1035	10.7	3.4	34	58	95	90		535	429	5	361	352	5.8													[illegible]	[illegible]	243
	06N 42E 16DC	4/30/74	63.0	14.2	8.39	1076	882	9.8	3.3	170	64	80	60		439	412	12	358	251	2.6		0.22	0.11	7.3	0.52	0.06	0.01				<.001	0.02	1.2	220	536
Tributaries																																			
Indian Creek	06S 39E 29BA	5/1/74	8.7	10.7	8.29	577	485	10.4	3.2	0	60	37	11		302	328	0	269	47	1.6		0.14	0.08	<.01	0.04	0.01	<.01	<.001			<.001		[illegible]	11	69.0
Davis Creek	04N 38E 11DB	2/28/74	2.6	0.0	8.23	1446	1145	12.9	4.5	12	74	87	112		544	551	0	452	317	3.8		0.22	0.03	0.24		0.02	0.01	<.01	<.01	<.01	<.001		2.1	2	6.0
	04N 38E 11DB	4/30/74	2.0	14.0	8.23	1685	1477	10.7	2.4	10	67	129	150		696	652	10	551	462	7.1		0.0	0.13	0.53	0.20	0.01	<.01	<.001			<.001		2.5	[illegible]	21.0
Muddy Creek	02S 40E 35CC	4/30/74	2.9	16.3	8.50	1317	1095	11.2	1.5	10	54	108	95		580	469	9	400	357	2.8		0.[illegible]	<.03	0.38	0.05	<.01	<.01	<.001			<.001		[illegible]	[illegible]	24.
Lame Deer Creek	02S 41E 28DB	1/30/74	3.0	0.00	7.98	1040	876	9.5	2.5	28	65	7[illegible]	54		466	519	0	426	163	0.2		1.1	0.11	0.05	0.02	<.01	<.01	<.01	<.01	<.01		<.01	1.1	[illegible]	10.0
	02S 41E 28DB	1/30/74	3.0	0.00	8.00	1126	947	11.8	7.5	550	63	82	69		493	534	0	438	192	4.1		2.9	0.40	1.1	0.14	<.01	<.01	<.01	<.01	<.01		.01	1.4	23	58.0
	02S 41E 28DB	4/4/74	2.0	4.5	8.40	1181	1034	13.5	4.0	130	70	86	83		530	557	15	482	212	8.8	.98	0.13	0.90	0.25	0.05	<.01	<.01	<.01		<.01	<.001		1.6	6	11.0

* See Appendix B2

stream. A sampling station on Pumpkin Creek was established by the Water Quality Bureau at the USGS stream flow station near the creek's mouth near Miles City. The bureau also established an upstream site on Pumpkin Creek near Volborg.

A few minor streams sampled in this subbasin in addition to those noted above were Youngs Creek near Decker, Squirrel Creek at Decker, Deer Creek near Decker, Stroud Creek near Otter, Logging Creek near Ashland, Cow Creek near Ft. Howe, and Little Pumpkin Creek near Volborg.

Unlike the reservoir on the Bighorn River (Yellowtail Reservoir), no extensive water quality study has been made on the Tongue River Irrigation Reservoir. A water quality and ecological study is planned for this reservoir as a part of the EPA's National Eutrophication Study.

Table 10-27 lists typical chemical analysis of surface waters in the Tongue River drainage. With the exception of samples collected from Logging and Cow Creeks, all of the samples collected on the tributary streams of the Tongue River, both major and minor, have relatively high specific conductances ranging from 975 to 6,570 micromhos per cm at 25°C. Like the waters in the Rosebud Creek drainage, samples on tributary streams to the Tongue had high ratios of magnesium to calcium. There is a general decrease in the concentrations of the dissolved constituents for each of the major tributaries from their upstream to their downstream station. Sodium and sulfate concentrations are quite high for these creeks, even during runoff periods. Flows of both the major and minor tributaries are usually at least two orders of magnitude less than that of the Tongue River. As a result, these streams are not likely to individually produce a significant load, but collectively, they probably degrade the waters of the Tongue River. This would be especially evident during early spring high flow periods of tributary streams, which precede the June high flow period for the Tongue River.

Specific conductance values for the Tongue River at the station line vary with flow from about 300 to 1,000 micromhos/cm at 25°C. The values of specific conductance for the Tongue River at Miles City vary from about 500 micromhos/cm at high flows to 1,100 at low flows.

v. Powder River

Several sites were sampled on the Powder River and its two major tributaries in Montana--Mizpah Creek and the Little Powder River. Samples were collected from the Powder River (1) near the state line at Moorhead, (2) downstream at Broadus at Powderville, and (3) near its mouth. The Little Powder River also was sampled near Broadus. Mizpah Creek was sampled in three locations: (1) its headwaters at Olive, (2) near Powderville, and (3) at a downstream location near its confluence with the Powder River at Mizpah. Sand Creek, a minor tributary of Mizpah Creek, also was sampled.

The water in this drainage basin (Table 10-28) is a sodium-sulfate type with bicarbonate a secondary anion. In contrast to most streams in the study area, chloride levels are relatively high in the Powder River drainage but chloride is not a predominant anion. Waters in the basin are moderately hard and have moderate to high concen-

TABLE 10-27

Typical chemical analysis of surface waters in the Tongue River sub-basin.

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Tongue River Mainstem																																			
at state line	09S 40E 33AB	3/18/69	2000		7.0	550					43	26	21	11		158	0		127	4.9	.4	3.7													
	09S 40E 33AB	6/3/70	2580	16.0	[illegible].0	314	188				32	14	10	1.4		128	0		5.6	1.0	.2	0.5		.180											
	09S 40E 33AB	5/24/72	1640	10.0	7.9	322	193				31	13	1.9			114	0		67	1.8	.2	0.9		.150											
	09S 40E 33AB	2/5/69	150		8.3	846	546				80	43	34	3.6		279	2		208	3.2	.4	2.0													
	09S 40E 33AB	12/10/70	230	0.0	8.1	820	535				78	49	34	3.8		311	0		200	4.6	.3	1.1		.120											
	09S 40E 33AB	2/2/72	210	0.0	7.7	810	519				78	44	30	3.3		270	0		200	5.0	.3	1.8		0.20											
	09S 40E 33AB	9/23/69	129		8.1	1030	708				84	62	55	4.4		318	0		293	5.6	.5	0.1													
	09S 40E 33AB	8/25/71	77	16.0	8.1	1060	732				91	61	61	6.9		331	0		340	5.4	.4	0.6		.100											
	09S 40E 33AB	8/23/72	217	18.5	[illegible].3	816	538				76	47	39	4.2		304	0		210	4.0	.4	0.3		.110											
at Miles City	07N 47E 23D	6/4/70	3360	20	7.9	503	322				49	23	25	3.3		196	0		114	0.8	.2	0.08		.046									0.9		
	07N 47E 23D	6/9/71	1840	19.0	7.8	467	295				35	20	33	3.[illegible]		152	0		110	5.4	.4			0.80											
	07N 47E 23D	3/9/72	2800	1.0	7.2	463	291				31	17	39	5.2		139	0		120	2.8	.2	0.16		.020											
	07N 47E 23D	1/8/70	150	0.0	8.0	1150	789				85	70	87	6.3		389	0		337	4.2	.4	0.05		.118									1.4		
	07N 47E 23D	1/12/71	172	0.0	8.0	966	690				91	54	72	5.1		369	0		280	4.5	.3			.140											
	07N 47E 23D	1/11/72	128	0.0	7.8	1120	755				80	58	88	4.3		363	0		330	6.3	.4			0.20											
	07N 47E 23D	8/4/70	243		8.2	580	366				45	26	40	3.5		213	0		134	2.6	.4			.149									1.8		
	07N 47E 23D	8/4/71	69	22.0	8.0	881	562				57	37	79	4.5		287	0		230	3.3	.7			0.20											
	07N 47E 23D	8/2/72	233	22.5	8.1	787	495				54	33	65	4.6		259	0		200	3.0	.3			0.20											
near Sheridan, WY	57N 84W 01	3/21/74	215E	3.7	8.31	647	522	13.4	3.5	2	59	39	26		310	267	4	225	125	1.0	.3	0.0	0.17	0.31	0.06	0.01	<.01	<.001	<.01	<.001	<.001		0.6	8	14.[illegible]
	57N 84W 01	5/8/74	1150E	11.3	7.83	236	179	10.0	4.3		26	8.7	5.5		102	112	0	92	25	0.5		0.16	0.17	1.2	0.09	0.01	<.01	<.001		.001	<.001		0.2	28	[illegible].5
near Decker, MT	09S 40E 22D	1/30/74	300	0.0	7.90	878	685	11.2			75	50	36		392	302	0	248	219	1.0		1.6	0.25	0.11	0.05	<.01	<.01	<.01	[illegible]	01		<.01	0.8	6	[illegible]
	09S 40E 22D	3/21/74	215	4.0	8.36	1061	853	13.3	3.4	2	83	67	59		486	306	5	259	330	2.0	.3	0.0	0.08	0.62	0.10	0.01	<.01	<.001		01	<.001		1.2	15	[illegible]
	09S 40E 22D	5/8/74	1150	13.0	7.90	312	235	9.1	3.2		31	16	6.9		144	128	0	105	53	0.0		0.35	0.15	1.4	0.06	0.01	<.01	<.001		.001	<.001	<.01	0.3	35	[illegible]
below Reservoir	06S 42E 27AA	3/21/74	217	3.8	8.33	956	694	13.8	3.7	0	73	47	56		376	240	5	205	270	2.0	.3	0.09	<.03	0.13	0.02	<.01	<.01	<.001		01	<.001		1.3	2	[illegible]
	06S 42E 27AA	5/9/74	860	11.2	8.12	801	650	10.0	3.9		67	45	51		352	254	0	208	230	3.0		0.11	0.03	0.35	0.07	0.02	<.01	<.001		001	<.001	<.01	1.2	5	[illegible]
near Birney	05S 43E 08DD	1/30/74	240	0.0	8.2[illegible]	910	717	11.7		2	70	53	52		391	299	0	245	242	1.2		0.60	0.0	0.06	0.04	<.01	<.01	<.01	[illegible]	01		<.01	1.1	4	[illegible]
	05S 43E 08DD	5/9/74	820E	14.8	8.3[illegible]	792	645	9.4	3.7		65	46	45		352	245	5	209	235	3.5		0.13	0.03	0.47	0.11	<.01	<.01			<.001	<.001		1.0	9	[illegible]
at Ashland	03S 44E 10BD	7/3/73	650E	23.5		315	232	8.9	3.2	29	25	14.0	17		120	133	0	109	42	0.8	.12	0.22	<.01	0.11			0.01	<.01	0.0[illegible]	01			0.7	23	[illegible]
	03S 44E 10BD	1/17/74	230	0.0	8.55	886	703	10.9	3.4	65	73	48	50			298	0		230	3.0	.27	0.54	0.10	2.7		<.01							1.1	[illegible]	[illegible]
	03S 44E 10BD	3/22/74	270	3.4	8.30	990	797	13.0	3.5	0	76	53	68		410	299	7	256	290	3.5		0.0	<.03	0.22	0.02	0.01	0.01	<.001		<.01	<.001		1.5	3	[illegible]
	03S 44E 10BD	5/9/74	780E	15.1	8.30	834	667	9.3	3.2		68	48	48		368	256	4	216	240	3.0		0.10	<.03	0.90	0.13	<.01	<.01	<.001		<.001	<.001		1.1	[illegible]	[illegible]
at Brandenburg	01S 44E 16DB	3/22/74	255E	3.0	8.32	1024	791	13.0	3.5	0	70	56	69		404	301	4	253	290	2.0	.3	0.14	<.03	0.30	0.04	<.01	<.01	<.001		01	.001		1.5	[illegible]	[illegible]
	01S 44E 16DB	5/9/74	740E	15.8	8.30	863	690	9.3	3.0		71	47	56		369	261	2	218	250	3.5		0.04	<.03	1.1	0.12	0.01	<.01	<.001		[illegible]	.001		1.3	26	[illegible]
near Garland	03N 47E 06BD	3/22/74	240E	2.5	[illegible].29	1073	773	12.9	4.6	0	46	71	65		408	268	0	220	320	2.0	.4	0.18	0.07	0.41	0.05	0.01	[illegible]	<.001		.01	.001		1.4	8	[illegible]
	03N 47E 06BD	5/9/74	700E	18.0	8.30	870	694	9.1	[illegible].5		67	50	54		373	268	0	220	250	4.0		0.04	<.03	1.7	0.16	0.01	<.01	<.001		.001	<.001		1.2	30	[illegible]
at Miles City	0[illegible] 47E 04DD	7/16/73	300	26.7		572	455	7.6	0.9	45	48	26	38		228	199	2	167	139	1.7	.19	0.24	0.02	0.03		0.03	<.01		[illegible]	.01			1.1	23	[illegible]
	07N 47E 04DD	3/22/74	225	0.0	8.25	1060	857	13.3	3.5	0	71	61	79		427	320	4	268	320	3.0	.3	0.0	<.03	0.50	0.04	<.01	<.01	<.001		.01	001		1.7	12	[illegible]
	07N 47E 04DD	4/25/74	425	20.3	[illegible].31	950	762	9.1	2.1	[illegible]	72	48	68		379	280	0	230	289	4.4		0.0	<.03	0.70	0.11	0.01	<.01	<.001			.001		1.5	21	[illegible]
	07N 47E 04DD	5/9/74	670	17.3	8.30	862	687	9.0	3.7		67	46	60		354	266	0	218	245	4.0		0.0	<.03	2.0	0.15	0.02	<.01	<.001			<.001	<.01	1.4	37	[illegible]
	07N 47E 04DD	6/10/74	1320	16.0	7.63	420	319	8.5	3.2		37	18	22		166	151	0	124	88	1.5		0.89	0.06	5.0	0.30	0.02	<.01	<.001		<.001	<.001	<.01	0.7	184	[illegible]
Tributaries																																			
Reservoir	08S 40E 25BB	3/21/74		2.7	7.99	775	601	13.6	5.3	0	65	45	36		346	253	0	207	200	2.0	.3	0.29	0.22	.011	0.02	0.01	0.01	<.001		<.01	<.001		0.8	2	4[illegible]
	08S 40E 25BB	5/8/74		17.2	8.20	475	359	11.8	5.1		42	25	16		208	170	0	139	105	1.5		0.22	0.06	0.35	0.05	0.01	<.01	[illegible]		<.001	<.001	<.01	0.5	9	1[illegible]
Youngs Creek	57N 84W	5/9/74	5.3	10.5	8.20	975	829	9.[illegible]	2.0		76	74	42		494	403	2	334	230	2.0		0.09	0.11	1.9	0.25	0.01	<.01	<.001		<.001	<.001		0.8	36	[illegible].0
Squirrel Creek	09S 40E 29CA	3/21/74	7.8	0.6	7.97	1724	1391	12.1	4.5	76	92	115	138		705	401	0	329	640	4.5		0.0	0.03	3.5	0.48	0.01	0.01	0.001		<.01	<.001		2.3	48	[illegible]
Deer Creek	09S 41E 10CC	5/8/74	0.3	20.2	7.98	5610	5299	13.1	4.4		279	312	875		1980	559	8	472	3250	16.5		0.0	<.03	0.50	0.35	0.02	<.01	<.001		<.001	<.001		8.6	8	29.[illegible]
Hanging Woman Creek W of Quietus	08S 43E 16DD	1/30/74	4E	0.0	7.77	1357	1066	8.4	7.8	6	62	57	174		210	0	0		556	4.7		1.9	0.70	0.77	0.11	<.01	<.01	<.01	<.01	<.01		<.01	3.8	14	20.0
	08S 43E 16DD	3/21/74	2.1	3.8	8.01	3963	3668	12.3	6.0	260	285	136	620		1270	536	0	439	2080	11.5		0.0	<.03	0.92	0.32	0.01	0.02	<.001		<.01	<.001		7.6	12	20.0
	08S 43E 16DD	5/16/74	0.4	15.0	8.30	4736	4196	10.3	2.9	2	196	230	725		1438	553	15	479	2464	11.8		0.0	0.02	0.80	0.12	<.01	<.01	<.001		<.001	<.001		8.3	16	33.0
Stroud Creek	08S 43E 02AC	5/16/74	0.07	10.5	8.21	2617	2179	18.0	2.3	13	85	126	372		732	603	18	525	966	8.6		0.0	<.03	0.15	0.02	<.01	<.01	<.001		<.001	<.001		6.0	3	8.0
Hanging Woman Creek nr Birney	06S 43E 19DD	1/30/74	12E	0.0	7.69	1488	1151	11.4	6.2	70	68	64	170		434	295	0	242	548	3.5		1.52	0.27	1.4	0.14	0.01	<.01	<.01		<.01		0.01	3.6	19	30.0
	06S 43E 19DD	3/21/74	2.9	4.0	8.17	2620	2308	12.5	3.2	0	120	127	371		821	592	0	485	1090	9.0		0.0	<.05	0.48	0.15	0.01	0.02	<.001		<.01	<.001		5.6	4	11.0
	06S 43E 19DD	4/4/74	2.9	4.8	8.16	2775	2349	11.5	3.2	72	83	160	375		866	604	11	513	1114	1.8	.91	0.0	0.05										5.5	11	19.0
	06S 43E 19DD	5/16/74	2.8	15.5	8.32	2814	2346	11.8	3.5	92	110	136	390		835	585	0	480	1115	10.6		0.0	<.03	1.4	0.17	0.01	<.01	<.001		<.001	<.001		5.9	24	70.0

* See Appendix B2

TABLE 10-27

(continued)

Sampling Site Designation	Sampling Site Location	Dates Sampled	Flow (cfs)	Temperature (°F)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Tongue River Mainstem																																			
Tributaries (continued)																																			
Logging Creek	03S 43E 15AA	4/18/74	0.5E	9.0	8.27	519	447	10.5	1.8	0	52	33	15		266	323	2	269	19	1.0	1.1	0.13	0.15	0.24	<.01	<.01	<.01	<.001		0.005			0.4	8	8.0
Otter Creek nr Otter	07S 45E 13DC	1/30/74	2E	0.0	7.82	3140	2698			12	169	169	375		1116	502	[illegible]	412	1468	8.6		7.1	0.05	0.52	0.30	<.01	0.03	<.01	<.01	<.01		0.01	4.9	11	23.0
	07S 45E 13DC	3/22/74	6.0	1.2	8.35	2776	2330	13.5	2.9	0	84	167	350		896	564	5	470	1150	10.0	.6	0.0	<.03	0.36	0.10	[illegible].01	[illegible].01	<.001		<.01	<.001		5.1	5	1.0
	07S 45E 13DC	5/16/74	0.3	10.5	8.21	3305	2786	18.0	3.9	4	162	193	390		1199	501	0	411	1530	10.1		0.16	<.03	0.15	0.02	<.01	<.01	<.001		<.001	<.001		4.9	3	2.0
Cow Creek	06S 45E 20AA	5/16/74	0.05	7.5	8.60	583	467	9.9	1.3	>200	47	36	28		264	267	10	235	78	1.6		0.0	.03	0.05	0.01	<.01	<.01	.001		<.001	<.001		0.8	2	2.0
Otter Creek nr Ashland	03S 44E 11AD	1/17/74	4.0	0.0	8.39	3339	2861	12.0	3.3	18	131	182	434		1075	750	0	615	1351	12.0	.79	0.47	0.06	0.46		0.01	0.02	<.01	<.01	<.01			5.8	4	14.0
	03S 44E 11AD	3/22/74	7.3	1.0	8.38	2359	2304	13.1	3.7	0	90	138	359		795	528	10	449	1070	8.5		0.0	.03	0.35	0.11	<.01	0.01	.001		<.01	<.001		5.5	10	16.0
	03S 44E 11AD	4/18/74	6.7	13.0	8.42	2961	2533	11.1	2.5	10	92	171	400		34	590	[illegible]	497	1270	1.5	.96	0.0	.03	0.53	[illegible].08	[illegible].01	0.01	.001		0.006			5.7	12	16.0
Little Pumpkin Cr	01S 48E 11BC	5/9/74	0.2	17.9	8.11	6570	6315	10.7	2.0		164	481	1050		2390	920	0	754	3700	0.0		0.0	.03	0.32	0.04	0.01	<.01	<.001		<.001	<.001		9.3	2	5.6
Pumpkin Creek near Volborg	01N 48E 11BC	4/18/74	0.1	13.0	8.30	5400	4766	9.2	3.4	0	166	218	956		1314	643	9	542	2773	0.0	.61	0.04	0.03	0.19	0.09	0.01	0.01	<.001		0.004			11.5	5	2.0
	01N 48E 11BC	5/9/74	0.09	16.3	8.32	5840	5394	9.1	3.2		139	253	1150		1391	673	12	572	3150	16.0		0.0	<.03	0.32	0.08	0.01	<.01	<.001		<.001	<.001		13.4	7	22.8
Pumpkin Creek S of Miles City	06N 48E 29AC	1/31/74		0.0	7.80	1035	815.6	11.9	3.8	[illegible]	65	49	90		363	306	0	251	304	1.2		0.87	0.02	0.23	0.02	<.01	<.01	<.01		<.01			2.1	10	11.0
	06N 48E 29AC	3/31/74	0.6	9.1	8.42	2564	2009	10.8	2.8	0	63	53	460		378	441	12	383	972	6.0	.32	0.0	0.05	0.30	<.07	0.01	<.01	<.01		<.01	<.001		10.3	[illegible]	13.0
	06N 48E 29AC	4/18/74	0.7	10.0	8.50	1977	1585	9.8	2.5	34	62	58	325		393	393	7	335	732	7.0													7.1	20	41.0
	06N 48E 29AC	5/9/74	0.5	19.0	8.43	3545	2759	9.4	5.9		67	58	690		403	528	7	445	1400	9.0		0.09	0.16	0.50	0.07	0.02	<.01	<.001	<.01	<.001	<.001	<.01	15.0	12	30.4
	06N 48E 29AC	5/20/74	42.7	11.5	8.33	2564	1931	10.0	5.7	5000	57	39	478		303	396	10	340	940	11.6		0.24	0.06	13.0	0.08	0.08	0.01	<.001			<.001		12.0	223	1016
Otter Creek at Ashland	03S 44E 11AD	5/9/74	5.0	18.2	8.35	3083	2776	10.0	3.9		80	182	470		950	621	12	529	1400	11.0		0.0	<.03	0.82	0.13	0.02	<.01	<.001		<.001	<.001		6.6	20	49.2

TABLE 10-28

TYPICAL CHEMICAL ANALYSIS OF SURFACE WATERS IN THE POWDER RIVER SUB-BASIN

Sampling Site Designation	Sampling Site Location*	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25°C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadmium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids T (mg/l)
Powder River at Moorehead	095 48E 17BB	6/16/53	5070	21.0	6.8	1490					259	47	48		838	212			740	6.0		0.2													
	095 48E 17BB	6/8/71	2000	16.5	7.5	950		8.0	2.2	2400	65	24							360	33															
	095 48E 17BB	3/19/56	2333	5.5	7.8	864					87	25	60		500	166			283	15		1.5													
	095 48E 17BB	3/1/72	4930	0.5	7.5	850		9.2	7.0	100	94	25	62						340	22	0.3										0.030				
	095 48E 17BB	9/3/53	28.0	19.5	7.7	1480					141	57	121		1031	172			665	9.0		5.4													
	095 48E 17BB	8/28/56	15.0	19.0	8.0	1380					140	49	95		985	140			605	13		8.7													
	095 48E 17BB	8/20/70	8.0	19.0	8.3	5000		9.0	2.3	29	228	132																							
	095 48E 17BB	9/2/71	7.7	28.5	8.5	2050		7.6	0.7	24	150	100							1100	35															
near Locate	08N 51E 14BC	3/29/51	3680	0.5	7.6	1250					104	41	120	4.6		190	0		470	34	0.5	5.6													
	08N 51E 14BC	3/30/52	22100	1.0	8.4	420					34	8.5	41			118	6		103	2.0		2.6													
	08N 51E 14BC	6/18/53	5393	20	7.0	1230					143	38	95		880	176	0		515	8.0		2.0													
	08N 51E 14BC	3/21/60	11470	1.5	7.4	676					71	15	53	6.2	328	183	0		183	6.2	0.3	3.6													
	08N 51E 14BC	8/19/59	1.43		7.7	2490					181	69	328	11	1261	274	0		1300	58	0.5	0.2													
	08N 51E 14BC	8/24/60	1.0		7.6	2790					183	79	375	11	1331	269	0		1190																
	08N 51E 14BC	9/2/61	1.0		8.1	2630					167	70	357		1169	255			1150	52	0.5	0.1		0.0											
Sunday Creek North of Miles City	08N 47E 03CC	3/31/74	0.6	9.6	8.41	2550	1667	10.7	1.4	0	64	27	460		269	266	6	228	470	374		0.0	.03	.26	.02	<.01	<.01	<.01		<.01	<.001		12.2	4	10.0
	08N 47E 03CC	5/20/74	75E	11.0	8.21	3274	2021	10.3	4.3	1030	81	31	563		331	219	0	180	570	556		0.47	0.03	12.0	0.28	0.08	0.03	<.001			<.001		13.5	210	1004
Powder River at Moorehead	085 48E 28CB	2/22/74	390E	0.2	8.02	1847	1367	12.4	2.7	0	108	52	230		484	282	0	232	560	133.		1.5	.17	.75	.05	.01	<.01	<.01			<.001		4.5	36	76.0
	085 48E 28CB	5/19/74	880E	13.6	8.22	1469	1025	9.4	2.6	475	93	35	175		375	188	4	160	439	92		0.17	0.06	19	6.8	0.09	0.02	<.001			<.001		3.9	220	1223
near Broadus	055 51E 03AD	7/3/73	550	26.5	8.30	1340	946	7.5	1.9	240	77	35	162		336	189	0	155	398	84.	.31	.35	.02	.09		5.0	<.01	<0.01	<.01	<.01			3.8	220	
	055 51E 03AD	2/21/74	390E	0.0	7.99	1688	1250	12.5	4.0	10	101	46	215		440	254	0	209	528	105.		1.3	.09	4.2	.26	.03	.01	<.01			<.001		4.5	170	793
	055 51E 03AD	5/20/74	880E	11.3	8.12	1467	1029	9.6	2.6	1170	95	37	168		390	188	0	154	454	87		0.12	0.06	25	0.85	0.12	0.03	<.001			<.001		3.7	180	1668
Little Powder River Southeast of Broadus	055 52E 28AA	2/21/74	60E	0.0	8.20	1846	1420	12.3	5.2	0	93	57	247		467	320	0	262	686	16.2		.76	.09	.82	.20	.01	.01	<.01			<.001		5.0	49	100
	055 52E 28AA	5/19/74	45E	13.8	8.11	3003	2364	9.8	3.0	180	128	92	456		698	453	0	371	1190	45		0.0	<.03	0.79	0.23	<.01	<.01	<.001			<.001		7.5	28	74.5
Powder River near Powderville	015 54E 17CA	2/22/74	450E	0.3	7.89	1720	1255.7	12.4	3.9	60	100	44	220		431	265	0	218	513	112.		1.3	.09	1.7	.10	.01	.01	<.01			<.001		4.6	75	250
Mizpah Creek near Olive	035 50E 26CC	5/20/74	0.0	9.3	7.78	3752	3307	6.6	1.5	4080	256	241	375		1632	470	0	385	1945	20		0.0	0.03	0.28	0.11	0.01	<.01	<.001			<.001		4.0	2	2.6
Mizpah Creek east of Volberg	02N 51E 09CD	2/22/74	1.5	1.8	7.62	1989	1584	9.8	4.7	10	71	52	333		391	355	0	291	769	3.0		.73	.09	.48	.27	.01	<.01	<.01			<.001		7.3	18	25.0
	02N 51E 09CD	5/20/74	0.8	10.3	7.89	3020	2432	10.0	3.1	196	114	83	494		626	521	0	428	1211	8.6		0.0	0.04	0.65	0.45	<.01	<.01	<.001			<.001		8.6	7	15.0
Sand Creek east of Volberg	02N 51E 08BB	5/20/74	0.0	11.0	8.24	5530	4819	6.9	3.2	56	115	121	1188		784	923	15	783	2456	0.2		0.0	0.05	.95	.32	.01	<.01	<.001			<.001		18.5	25	55.0
Mizpah Creek near Mizpah	06N 51E 24BD	2/21/74	12.3	0.3	7.58	1674	1235	12.2	6.6	0	48	33	270		254	307	0	252	570	5.5		1.0	.09	.68	.10	.01	<.01	<.01			<.001		7.4	36	70.0
	06N 51E 24BD	7/11/74	0.4	24.2	8.71			7.5	5.9	50																								40	70.0
Powder River near Locate	08N 51E 23CD	2/21/74	450	0.0	7.40	1745	1263	12.8	4.6	10	97	44	222		422	267	0	219	525	106.		1.5	.09	2.0	.10	.01	.01	<.01			<.001		4.7	120	275
	08N 51E 23CD	7/10/74	170	25.0	8.02			7.6	5.7	830																								260	1100
Powder River southwest of Terry	11N 50E 03DC	7/17/73	67	22.8	8.20	2309	1797	7.9	2.1	68	131	54	350		549	233	0	191	935	93.	.39	.28	.01	.03		.03	<.01	<.01	<.01	<.01			6.5	61	
	11N 50E 03DC	4/25/74	2300	18.1	7.57	2998	2205	5.4	2.9	144	190	79	375		802	254	0	209	1190	116		0.31	0.04	5.3	14	1.8	0.22	0.01			<.001		5.8	>1000	62800
O'Fallon Creek near Ismay	08N 56E 30DA	10/18/73	6.6	9.0	8.10	2695	2326	9.5	2.3		60	61	540		400	583	0	478	1075	6.0	.52	.25	.04	.31		<.01	.01	<.01	<.01	<.01			11.7	24	
O'Fallon Creek near Fallon	12N 52E 03DA	7/17/73	15.4	26.2	8.50	2067	1712	7.8	1.7	0	58	53	380		363	353	10	305	847	11.4	.37	.39	.02	.02		.05	<.01	<.01	.01	<.01			8.7	4	
	12N 52E 03DA	4/25/74	28.8	22.0	8.46	2890	2290	8.3	1.6	110	82	75	500		514	437	0	358	1177	18.4		0.0	0.04	0.10	0.05	0.02	0.01	<.001			<.001		9.6	4	5.2
Yellowstone River near Fallon	13N 52E 27AC	4/25/74	14500	16.5	8.05	1144	847	7.4	3.9	104	71	38	123		333	211	0	173	372	31		1.4	0.04	93	3.8	0.47	0.08	0.003			<.001		2.9	>1000	9450

* See Appendix B2

trations of dissolved minerals. Tributary streams generally had higher dissolved mineral concentrations than the mainstream river. In general, there are no distinct downstream changes in water quality in the Powder River from Moorhead to its mouth near Terry.

A major factor in water quality in the Powder River is suspended sediment. Values greater than 200 mg/1 were common with an extreme value of 62,800 mg/1 measured during a spring high flow period; 33% of the sample volume was found to be settleable solids at that time. During periods of above-average flow, the Powder River has a significant effect on sediment concentrations in the Yellowstone River. As an example, in April of 1974, settleable solids in the Yellowstone increased from near zero percent by volume at Miles City to 8% at Fallon below the confluence of the two streams; suspended solids increased from 116 to 9,450 mg/1.

vi. Yellowstone River

The USGS has maintained a water quality station at Miles City on the Yellowstone River. Several new stations are expected to be installed on the Yellowstone by the USGS in the next year in response to coal developments in this part of Montana. The Water Quality Bureau sampled the Yellowstone River at Myers, Forsyth, Rosebud, and Miles City.

Major tributaries to the Yellowstone River in this drainage (the Bighorn River, Rosebud Creek, and the Tongue River) have all previously been described. Of the minor creeks sampled by the Water Quality Bureau in this drainage, Sarpy and Armells Creeks are of interest due to developments occurring within their drainages. The USGS has established water quality stations on these creeks near their confluences with the Yellowstone River. However, no data has yet been published from these sites. The Water Quality Bureau established sampling sites on these two creeks at the USGS station downstream and also in their upper drainages.

Data in Table 10-29 presents typical water quality data for six sites in the Yellowstone River between Custer and Fallon. These data indicate that the concentration of dissolved minerals increases significantly downstream from the confluence with the Big Horn River. The Big Horn River has a significant impact on the quality of water in the Yellowstone during periods of low flow in the Yellowstone. The major downstream impact on the Yellowstone River is from the Powder River, especially during periods of high flow in this tributary stream. This is most readily evident in the increase in sediment and turbidity, although other parameters, such as specific conductance and dissolved solids, also show an increase below the confluence of the two rivers.

The Yellowstone River is a calcium sulfate-bicarbonate stream. Sulfate concentrations are generally slightly higher than those for bicarbonate, and chloride concentrations are insignificant. Magnesium is also abundant but the concentrations of this mineral are generally less than calcium concentrations. Dissolved solids in the Yellowstone River within the study area range from about 200 to 850 mg/1 and vary with stream location and flow. Concentrations

TABLE 10-29

Typical chemical analysis of water in the Yellowstone River sub-basin-- Bighorn River to Tongue River.

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Yellowstone River Mainstem																																			
at Myers	06N 35E 21DB	1/22/74	7680	0.0	7.78	729	538	12.2	3.8	70	65	18.9	58		240	174	0.0	143	210	8.5		3.2	0.13	1.6	0.08	<.01	<.01	<.01			0.002		1.6	39	94.0
	06N 35E 21DB	4/25/74	12360	11.9	8.13	759	573	10.2	1.9	20	57	28	66		259	194	0	159	218	8.8		0.66	0.10	1.4	0.11	0.02	<.01	<.001			<.001		1.8	26	76.0
	06N 35E 21DB	4/25/74	12360	13.1	8.08	693	518	10.0	1.9	34	60	21	58		237	184	0	151	185	9.4		0.64	0.11	1.1	0.10	0.02	<.01	<.001			<.001		1.6	22	58.0
at Forsyth	06N 40E 22AA	7/16/73	10800	23.8	8.30	450	342	8.9		9	3.7	15	37		154	131	0.0	107	117	4.6	.31	0.19	0.06	0.02			<.01	<.01	<.01	<.01			1.3	13	
	06N 40E 22AA	12/13/73	7400	2.0	7.89	782		12.8	2.6	1														0.21		<.01	<.01	<.01	<.01					6	8.8
	06N 40E 22AA	3/13/74	7740	5.6	8.41	790	660	12.1	2.9	0	74	26	81		292	193	7.0	169	268	10.4	.46	0.32	0.12	0.39	0.04	0.01	0.01	<.01	<.01		<.001		2.1	4	11.0
	06N 40E 22AA	4/25/74	11870	14.3	8.18	704	552	9.3	2.1	130	63	23	63		251	192	0	158	200	9.6		0.70	0.11	1.7	0.12	0.02	<.01	<.001			<.001	<.01	1.7	38	104
	06N 40E 22AA	6/10/74	33800	12.8	8.22	499	357	8.7	3.6		43	9.1	46		145	122	0	100	131	5		0.49	0.15	12	0.52	0.07	0.01	<.001			<.001		1.7	210	992
	06N 40E 22AA	6/20/74	61800	18.5	8.21	250	200				32	4.2	17		97	99	0	81	44	3.3		0.78	0.24	9.0	0.42	0.04	0.01	<.001		.001	<.001	0.02	0.8	300	
near Rosebud	06N 42E 15BC	1/21/74	9570E	0.0	7.94	622	467	12.3	4.6	20	54	18	52		208	151	0.[illegible]	124	183	7.0		2.1	0.13	1.6	0.03	<.01	<.01	<.01			0.002		1.6	28	54.0
	06N 42E 15BC	3/13/74	7830	6.0	8.40	810	668	12.3	3.3	10	72	28	81		294	202	5.0	174	270	9.6		0.66	0.11	0.66	0.05	<.01	<.01	<.01	<.01		<.001		2.1	6	14.0
	06N 42E 15BC	3/13/74	7830	6.0	8.40	800	652	12.2	2.9	10	71	27	80		286	179	12	167	273	9.0	.48	0.62	0.06	0.29	0.05	<.01	<.01	<.01	<.01		<.001		2.1	3	10.0
	06N 42E 15BC	4/25/74	11380	14.4	8.11	688	560	9.4	2.1	84	63	24	64		254	191	0	157	208	8.8		0.70	0.12	1.7	0.11	0.02	0.01	<.001			<.001		1.7	38	104
at Miles City	08N 47E 28BB	7/16/73	11100	24.7	8.51	582	350	9.0	1.9		39	16	35		165	132	4.0	114	118	4.1	.31	0.89	0.01	0.02		0.03	<.01	<.01	<.01	<.01			1.2	14	
	08N 47E 28BB	3/31/74	9300	8.7	8.38	847	638	11.1	1.1	[illegible]	69	29	75		292	190	5.0	164	261	9.1		0.32	0.06	0.30	0.03	<.01	<.01	<.01		<.01	<.001		1.9	6	14.0
	08N 47E 28BB	4/25/74	11800	17.0	8.21	686	578	9.1	2.1	108	65	23	63		259	189	0	155	227	9.6		0.78	0.11	1.8	0.12	0.02	0.01	<.001			<.001	<.01	1.7	42	116
	08N 47E 28BB	6/11/74	35100	13.6	7.58	441	342	8.7	3.8		43	11.2	40		152	122	0	100	120	5.5		0.67	0.12	0.97	0.51	0.06	<.01	<.001		<.001	<.001		1.4	185	760
	08N 47E 28BB	6/11/74	35100	12.8	7.83	485	337	8.0	3.2		39	11.5	42		145	113	0	93	124	5.8		0.93	0.15	11.0	0.44	0.06	0.01	<.001		<.001	<.001		1.5	220	926
at Miles City	08N 47E 31BC	6/3/70	31100	17.0	7.9	439	265				39	14	30	2.6		142	0.0		91	3.2	.3			.614											
	08N 47E 31BC	6/7/71	32000	15.0	8.1	403	255				36	12	29	1.9		123	0.0		98	3.9	.3		0.09	0.04											
	08N 47E 31BC	6/7/72	48400	20.0	6.8	247	150				23	70	15	1.5		83	0.0		47	2.8	.3			0.08											
	08N 47E 31BC	12/9/68	7640	0.0	7.7	702					57	22	61	3.9		189	0.0		202	9.6	.4	2.2		.180											
	08N 47E 31BC	12/2/69	6800	1.0	7.9	764	499				61	25	69	4.4		196	0.0		223	9.0	.6			.046											
	08N 47E 31BC	12/7/70	6840	0.5	7.0	668	443				58	21	55	4.1		192	0.0		190	9.8	.4			.060											
	08N 47E 31BC	9/9/69	6900	20.0	8.1	724					59	23	70	4.3		196	0.[illegible]		210	6.8	.5	0.10		.090											
	08N 47E 31BC	9/9/70	6610	17.0	7.6	625	401				51	18	54	4.1		178	0.0		166	9.2	.5														
	08N 47E 31BC	9/1/71	10300	22.0	7.6	534	340				41	15	46	3.4		167	0.0		130	8.1	.9		0.06	.030											
Tributaries																																			
Alf Creek	07N 36E 22DC	2/9/74	.2	1.5	7.00	146	86	12.0	8.0	235	9.0	3.3	12		36	38	0	31	20	2.2		0.91	0.69	7.8		0.07	<.01	<.01	<.01		<.001		0.9	128	184
Froze-to-Death Creek	07N 36E 26AA	2/9/74	.2	1.0	7.17	132	108	11.7	4.9	[illegible]	7.1	2.0	20		26	33	[illegible]	27	44	0.6		0.42	0.61	2.8		<.01	<.01	<.01	<.01		<.001		1.7	66	96.0
Sarpy Creek																																			
below Westmoreland	01N 37E 16DA	1/18/74	25.9	0.0	7.01	283	187	11.1	>11.1	500	18.8	9.2	20		85	76	0	62	56	5.0	.05	1.3	0.92	22		0.01	<.01	<.01	<.01	<.01			0.9	82	190
		1/31/74	0.0	0.0	7.40	2584	2245	4.7	2.4	11	142	203	194		1188	640	0	525	1059	6.3		1.25	0.10	0.67	1.1	0.03	<.01	<.01	<.01	<.01		0.01	2.4	4	5.0
		3/19/74	1.0	1.0	8.00	2270	2041	10.5	4.1		120	177	196	12	1028	608	0	498	920	8.0	.27	0.0	<.03	0.60	0.11	<.01	0.02	<.001		<.01			2.7	8	6.0
E of Hysham	06N 37E 18AB	12/27/73	2.8	0.0	8.31	2395	2037	12.8	3.0	18	86	78	400		535	576	0	472	883	14.2	.43		0.01	0.31		0.01	<.01	<.01	<.01	<.01			7.3	5	6.0
	06N 37E 18AB	2/9/74	3.7	0.0	8.20	1793	1390	11.4	2.8	20	74	62	238		440	426	0	349	582	7.2		0.78	0.25	0.60		<.01	<.01	<.01	<.01		<.001		4.9	[illegible]	9.5
	06N 37E 18AB	4/17/74	3.2	10.5	8.34	2656	2269	10.4	2.7	29	91	129	385		758	556	0	456	1096	11.8													6.1	10	14.0
	06N 37E 18AB	6/11/74	30.2	16.7	8.12	2205	1849	8.1	6.3		107	[illegible]	325		630	329	25	311	962	12.5		0.06	0.06	3.0	0.17	0.02	<.01	<.001		0.002	<.001	0.01	5.6	51	159
Starved-to-Death Creek	07N 37E 26AC	2/9/74	0.9	1.0	6.80	1768	1313	12.0	4.2	80	63	39	296		318	18	0	15	886	3.6		6.6	0.0	5.8		0.04	<.01	<.01	<.01		<.001		7.2	98	220
	07N 37E 26AC	4/19/74	0.01	17.7	7.39	2263	1669	9.8	3.4	0	95	43	360		417	41	0	34	1124	4.0	.46	0.0	0.03	0.16	<.01	0.01	0.01	<.001			<.001		7.7	[illegible]	6.5
Reservation Creek	06N 38E 35CB	12/27/73	0.9	0.0	8.45	1945	1637	12.9	1.9	5	96	69	278		525	436	[illegible]	357	745	12.6	.34		0.01	0.18		<.01	<.01	<.01	<.01	<.01			5.3	4	3.5
	06N 38E 35CB	2/16/74	1.2	2.0	8.00	1591	1513	12.2	2.7	110	98	69	244		530	432	0	354	660	9.4		0.47	0.12	0.49		0.01	<.01	<.01	<.01		<.001		4.6	11	23.5
	06N 38E 35CB	4/19/74	0.8	13.0	7.89	1918	1356	10.5	2.5	74	91	69	198		512	458	0	375	539	0.5	.52	0.0	0.03	0.54	0.01	0.01	0.01	<.001			<.001		3.8	12	21.5
Great Porcupine Creek	06N 39E 11CA	11/30/73		0.0	7.39	2050	1698				150	60	257		621	451	[illegible]	370	744	35		0.39	0.04										4.5	[illegible]	
	06N 39E 11CA	1/24/74	0.5	0.0	6.61	1071	695	11.1	8.2	0	51	11.1	145		174	63	0	52	410	5.0		8.3	0.31	1.5	0.01	<.01	0.01	<.01			0.002		4.8	27	62.0
	06N 39E 11CA	4/18/74	0.0	16.8	7.92	2066	1627	10.4	4.3	2	112	66	275		554	247	0	203	910	15.0	.44	0.0	0.03	0.78	0.22	0.01	<.01	<.001			<.001		5.1	16	28.0
Armells Creek																																			
E Fork at Colstrip	01N 41E 03BB	10/24/73	0.2		8.20	3850	3679				285	362	272		2200	644	0	528	2078	38	.33	0.45	0.86	0.40		0.04	<.01	<.01	0.01	<.01			2.5	1	
	01N 41E 03BB	1/25/74	0.05	2.0	7.21	2826	2584	1.9	1.9	[illegible]	261	220	160		1555	602	[illegible]	494	1328	12.8		0.78	0.28	2.7	3.0	0.06	0.01	<.01			<.001		1.8	39	39.0
	01N 41E 03BB	4/16/74	0.2	11.8	7.81	3055	2845	10.7	2.4	0	228	281	173		1728	599	0	491	1563	0.2	.30	0.04	<.03	0.41	1.5	0.03	0.01	<.001			<.001		1.8	4	7.2
E Fork N of Colstrip	03N 41E 28CC	3/14/74	0.9	4.1	7.97	5043	4885	12.5	5.0	1	207	487	525		2520	592	0	485	3048	26	.27	0.19	0.09	0.78	0.51	0.02	0.01	<.01	<.01		<.001		4.6	11	26.0
	03N 41E 28CC	4/16/74	2.0	15.0	8.10	4858	4686	11.9	2.8	36	248	452	488		2480	558	0	458	2904	35	.22	0.0	<.03	0.38	0.18	0.01	0.01	<.001			<.001	0.02	4.3	8	18.0
E Fork at Hwy 315	04N 40E 22CA	1/25/74	2.8	2.2	7.98	2096	1639	10.5	4.0	0	124	91	228		682	285	0	234	891	20		0.75	0.11	0.08	<.01	<.01	0.03	<.01			0.001		3.8	2	3.8
	04N 40E 22CA	4/16/74	2.2	24.0	8.31	4460	4002	8.0	1.7	0	216	212	669		1412	506	[illegible]	419	3286	9.0	.31	0.18	0.03	0.34	0.21	0.01	0.03	<.001			<.001		7.7	20	28.0

* See Appendix B2

TABLE 10-29

(continued)

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness CaCO$_3$ (mg/l)	Bicarbonate HCO$_3$ (mg/l)	Carbonate CO$_3$ (mg/l)	Alkalinity CaCO$_3$ (mg/l)	Sulfate SO$_4$ (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO$_3$ (mg/l)	Phosphate PO$_4$ (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Yellowstone River Mainstem																																			
Tributaries (continued)																																			
Armells Creek																																			
Upper West Fork	03N 39E 26AC	4/14/74	1.6	15.0	8.20	5440	5026	9.50	1.5	6	192	301	888		1720	640	5	533	2999	0.2	.27	0.0	<.03	0.25	0.07	0.01	0.01	<.001			<.001		9.3	17	16.8
W Fork nr Hwy 315	04N 40E 16AB	1/25/74	3.1	2.0	7.92	3272	2769	11.0	4.4	0	167	132	468		962	412	[illegible]	338	1570	17.8		1.6	0.17	0.39	0.26	<.01	0.02	<.01			<.001		6.6	2	10.5
	04N 40E 16AB	4/15/74	2.8	11.6	8.16	4190	3604	11.3	4.0	190	176	164	675		1116	522	5	436	2049	12.0	.44	0.0	<.03	0.65	0.15	0.01	0.01	<.001			<.001	0.04	8.8	18	28.0
at Highway 315	05N 39E 36BB	1/25/74	4.5	0.0	7.96	2280	1735	11.7	6.0	0	104	68	323		540	318	0	261	908	13.3		0.66	0.11	0.61	0.20	0.01	0.01	<.01			0.004		6.0	15	37.3
	05N 39E 36BB	4/16/74	4.2	13.5	8.21	3210	2634	11.3	3.6	32	124	97	538		710	413	0	339	1444	17.0	.27	0.06	0.03	0.35	0.33	0.02	0.01	<.001			<.001	0.05	8.8	36	38.0
W of Forsyth	06N 39E 23AC	12/14/73	1.9	3.1	8.32	3880		13.3	2.1	2														0.16		0.02	0.01	<.01	0.01					8	24.8
	06N 39E 23AC	1/22/74	9.2	0.0	7.80	1006	701	11.6	11.0	1120	62	58	138		178	194	0	159	292	8.2		1.4	0.23	3.4	0.15	0.01	0.02	<.01			0.01		4.5	72	180
	06N 39E 23AC	3/1/74	2.3	4.7	8.18	2914	2301	11.8	4.7	260	63	70	525		447	512	[illegible]	420	1118	12.0		0.31	0.49	1.8		0.02	<.01	<.01	<.01	<.01	<.001	0.01	10.8	33	64.0
	06N 39E 23AC	4/16/74	4.2	14.0	8.23	2628	2095	11.0	3.5	212	92	67	441		504	380	0	312	1100	14.0		0.27	0.06	1.8	0.21	0.02	<.01	<.001			<.001	0.05	8.5	43	93.0
	06N 39E 23AC	4/17/74	4.2	13.5	8.31	3304	2796	10.9	3.6	50	99	99	606		656	463	6.0	389	1500	23													10.3	26	64.0
	06N 39E 23AC	6/20/74	18.3	27.2	8.21	650		8.4			39	13	82		152	134	0	110	204	5.5		0.55	0.17	9.2	0.32	0.03	<.01	<.001		.005	<.001	0.01		270	380
Sheep Creek	04N 40E 22BB	4/16/74	0.1	18.2	8.12	703	514	8.4	5.3	0	11.2	2.9	138		40	180	0	148	170	2.0		8.0	0.92	1.8	0.16	0.14	0.03	<.001			<.001		9.5	155	245
Smith Creek	06N 40E 28AA	2/9/74	0.3	1.5	8.17	1762	1377	11.7	2.9	0	44	29	312		230	529	0	434	462	0.2		0.53	0.04	0.36	0.04	0.01	<.01	<.01			<.001		8.9	[illegible]	11.5
	06N 40E 28AA	4/19/74	0.2	12.3	8.23	2154	1778	10.4	1.6	0	46	34	431		256	608	10	516	648	0.0	.80	0.0	0.03	0.20	<.01	0.01	0.01	<.001			<.001	0.03	11.7	14	17.6
Little Porcupine Creek	06N 41E 02DC																																		
	06N 41E 02DC	11/29/73		0.0	7.31	3480	1077				77	26	208		299	290	[illegible]	238	422	48		4.76	0.03										5.2	13	
	06N 41E 02DC	2/9/74	2.3	0.0	7.72	3821	3106	10.2	3.1	10	353	95	476		1272	275	0	211	1667	257		1.2		0.35	0.34	0.01	<.01	<.01			<.001		5.8	11	16.0
	06N 41E 02DC	4/18/74	2.9	15.0	7.81	4802	3958	10.5	4.1	6	465	106	594		1598	203	0	167	2238	349	2.7	0.0	0.06	0.90	0.50	0.01	0.02	<.001			<.001	0.04	6.5	24	38.0
Sweeney Creek	06N 43E 22AD	1/21/74	1.5	0.0	7.78	807	606	11.8	10.1	460	57	0.0	116		142	218	0	179	205	8.3		1.9	0.18	1.8	0.08	<.01	0.01	<.01			0.001		4.2	53	108
	06N 43E 22AD	4/18/74	0.7	19.5	8.41	2073	1682	10.6	2.6	2	50	34	400		266	504	10	431	670	12.0	.86	0.0	0.03	0.89	0.11	0.01	<.01	<.001			<.001		10.7	23	37.0
Moon Creek	07N 46E 30DA	3/31/74	0.2	9.2	8.30	2200	1728	10.7	1.1	0	67	40	388		334	481	20	428	716	14.8	.25	0.0	0.03	0.23	0.06	<.01	<.01	<.01		<.01	<.001		9.2	2	4.5
	07N 46E 30DA	6/10/74	1.3	16.2	7.72	962	732	8.4	6.4		39	0.8	179		101	231	9	204	268	4.7		0.68	0.29	6.5	0.18	0.06	<.01	0.001			<.001		7.7	205	482

* See Appendix B2

decline with increased flow, and increase downstream. As examples, for the Yellowstone at Forsyth, dissolved solids range from 200 mg/l at a high flow period in June (61,800 cfs) to 660 mg/l at a low flow period in March (7,740 cfs). On the same date in April, dissolved solids range from 287 mg/l at Custer above the Big Horn River to 847 mg/l near Fallon. Numerous small tributaries such as Rosebud and Armells Creeks entering the Yellowstone River between these two points probably have a cumulative effect on the river also, although the individual effect of these streams is small.

Suspended sediment concentrations vary widely in the Yellowstone in response to flow. Sediment concentrations are commonly less than 50 mg/l during low flow periods and increase over 900 mg/l during the high flow period in June. Upstream from the Powder River there is a general tendency for suspended solids to increase downstream in the Yellowstone River. A significant increase in sediment load occurs in the Yellowstone below its confluence with the Powder River.

Armells Creek: Eight stations were established on Armells Creek and its tributaries. Three sites were sampled on its east fork: (1) at Colstrip, (2) about seven miles below Colstrip, and (3) about 13 miles below Colstrip near its confluence with the west fork. Two sites were established on the west fork of Armells Creek: (1) an upper site near its headwaters, and (2) a lower site just above the confluence of the two forks of the stream. Two additional sites were located on mainstem Armells Creek: (1) immediately below the confluence of the east and west forks, and (2) just above the Yellowstone River. Samples also were obtained from a small tributary stream of Armells Creek (Sheep Creek).

Table 10-29 shows typical water quality data for Armells Creek. In the immediate vicinity of Colstrip, this creek is a calcium-magnesium-sulfate type water. However, the remainder of the creek is a sodium-sulfate type water. Waters of the stream are relatively hard and are distinctive in their high specific conductances, and therefore, high dissolved solids concentrations. Magnesium and sodium are dominant cations and sulfate is the dominant anion. Chloride is present in low concentrations and the bicarbonate ion is of secondary importance. Iron and manganese concentrations commonly exceed U.S. Public Health Service drinking water standards. Other trace elements including copper, zinc, chromium, cobalt, vanadium and boron have been identified in the stream.

In general, the quality of water in Armells Creek may be described as poor. However, this quality improves downstream in the creek with marked reduction in the concentration of dissolved minerals. Specific conductances range from near 5,000 micromhos/cm in the stream's headwaters to near 1,000 micromhos/cm at its mouth during periods of above average flow runoff conditions. During periods of normal or low flow, conductivities in both the headwaters and near the mouth are significantly higher than during periods of above average runoff.

Generally, turbidity and suspended sediment concentrations are low to moderate and generally increase in a downstream direction.

Sarpy Creek: Table 10-29 presents the water quality data obtained for Sarpy Creek at an upstream site near Westmoreland and at a downstream site near Hysham. Like Armells Creeks, this stream has hard, sodium-sulfate type waters. Specific conductances were generally greater than 2,000 micromhos/cm with a typical dissolved solids concentration of 2,000 mg/1. The upstream and downstream sites were similar in their dissolved solids concentrations, although the upstream site has a higher proportion of calcium and magnesium. Water quality at both locations on Sarpy Creek is poor.

Flows of these two creeks are normally small, thus they do not have a significant effect on the Yellowstone River. However, periods of high flow in minor streams in the drainage do not generally coincide with the periods of high flow on the Yellowstone, thus small creeks during high flow periods may collectively degrade the quality of water in the Yellowstone River.

10.1.3.2. Ground Water

Ground water is water beneath the earth's surface in saturated rock. Water also exists above the zone of saturation but it is not available for withdrawal by wells. Rocks possessing considerable porosity and permeability which act as reservoirs and conduits for ground water are called aquifers. Sandstone, gravel, alluvium, carbonates, coal, clinker, and highly fractured rock may store and conduct water. Unfractured, impervious rock, such as clay or shale, restrict ground water movement and are called aquicludes. Together, the aquifers and aquicludes in a particular area form the ground water system which supplies springs, wells, and certain streams with water, and is recharged by rainfall, melting snow, and some streams. Ground water systems are dynamic ones, responding to changes in climate and those initiated by the works of man.

A. Water Quantity

1. Regional Ground Water System

The Fort Union and Upper Cretaceous formations, (see Figures 10-20 and 10-21 in Section 10.1.4.) contain numerous sandstone bodies, coal beds, and clinker. These rocks, together with terrace gravel and alluvium along the streams, form the important shallow aquifers. The restricted size and shallow depths of most of these aquifers result in local ground water systems. The regional ground water system involves much deeper formations.

During oil drilling operations in the Powder River Basin, it was discovered that certain deep formations were aquifers. One well in the Bell Creek oil field in southeastern Powder River County was reported to yield 30,000 barrels of water per day (1.26 X 10 gallons/day or 2 cfs). Montana Power Company drilled an exploratory well at Colstrip to determine the feasibility of using deep aquifiers to supply water for their power plants. This well reached a total depth of 9336 feet and penetrated three aquifers-the Mission Canyon (Mississippian), Lodgepole (Mississippian) and Red River (Ordovician). The Mississippian formations and the equivalent of the Red River (Bighorn dolomite) crop out in the Bighorn Mountains about 80 miles southwest of Colstrip. The

Madison limestone (Mission Canyon and Lodgepole formations) also crop out over a large area on the west side of the Black Hills uplift. These two mountainous regions are almost certainly recharge areas for these aquifers (Figure 10-18). This conclusion is supported by the high static pressure at the wellhead (about 200 pounds per square inch). Percolation of the water through the sediments within the Powder River Basin would not be expected to generate such pressures. There are also thick sequences of shale which not only act as confining beds for the artesian system but would also prevent vertical recharge.

Any decision concerning the use of the deep aquifers as a source of industrial water must consider: (1) amount of water available; (2) number of needed wells; (3) well spacing; and (4) quality of the water.

Flow rates were measured and well spacing was estimated, from the Colstrip well. After an extended period of maximum free-flow, the discharge was about 240 GPM (.54 cfs) and the water temperature was 207°F. Pumping could increase the yields from any one well.

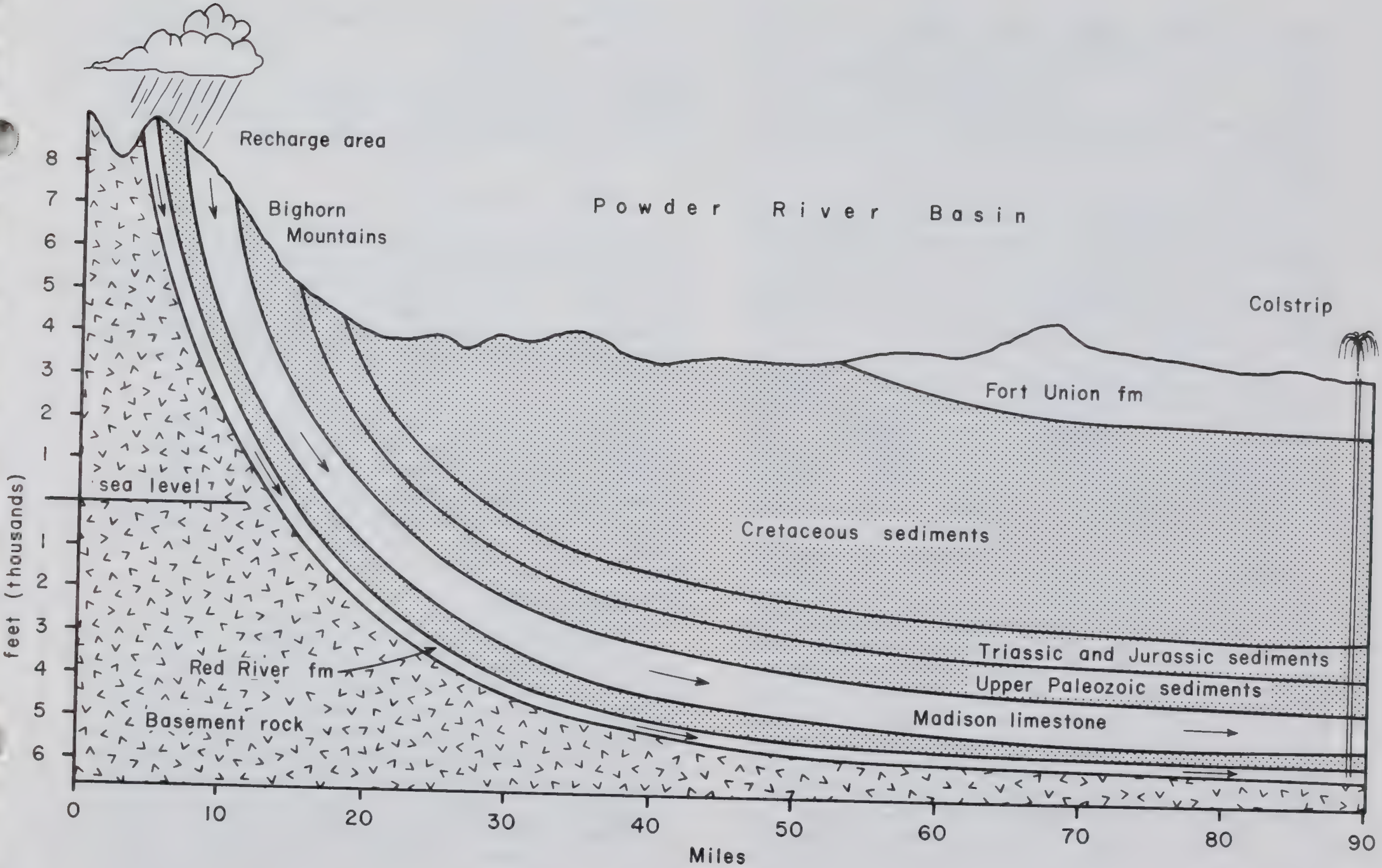
Well spacing could be partly determined using the radius of influence of the wells. The radius of influence is the distance that the well would influence other wells. Accurate estimates of this distance are difficult when using only one well. VanVoast (1974) of the Montana Bureau of Mines and Geology, has estimated that this well would have a radius of influence of about 100,000 feet (20 miles), but it could be as little as 10,000 feet or as great as 1,000,000 feet. If wells were spaced so that their radii of influence overlapped, production from each well would be reduced, resulting in the need for more wells or greater pumping.

Little is known concerning deep aquifers and the small amount of information gathered at the Colstrip test well and other wells within the Powder River Basin does not give an understanding of all the problems that might be involved in the exploitation of this water. For instance, we do not know what the recharge rates are. If the regional recharge rate is smaller than the regional pumping rate for all purposes, then the water will be mined, and the resource will have a finite life span. Other consequences of extensive pumping from the deep aquifers are similarly unknown.

2. Local Ground Water Systems

Local ground water systems are composed mostly of coal, sandstone, and clinker of the Fort Union formation. Along the larger streams, alluvium can yield moderate quantities of water at shallow depths, though this water is often hard (Renick 1929). Terrace gravels of Pleistocene age or older are good aquifers in some cases, yielding some of the best ground water in the area (Renick 1929).

Most of the water in the Tongue River member is found in the coal seams. The coal's porosity and permeability is due to fracturing. Many of the coal beds are underlain by an impervious clay, which, coupled with the persistence of some coal, makes these coal beds important aquifers. Where the thicker seams have burned near their outcrop, the overburden has been altered to clinker, a highly fractured and permeable rock.



GENERALIZED CROSS SECTION FROM BIGHORN MOUNTAINS TO COLSTRIP SHOWING SOME MAJOR PALEOZOIC AQUIFERS AND GROUNDWATER MOVEMENT

Figure 10-18

Large areas of clinker lying up-dip of the coal bed probably recharge the coal with some of its water (Van Voast 1974). Sandstone also plays an important role in the local ground water systems. Based upon surface area covered by sandstone, this rock recharges both the sandstone and coal aquifers.

Near Colstrip, the Rosebud coal seam is an important aquifer. The McKay coal seam, which underlies the Rosebud but with a slightly greater areal extent, is important in areas where it extends beyond the Rosebud. Several other near-surface aquifers are also used.

Because ground water flows about in an aquifer to supply wells, springs, and streams, this movement is an important characteristic of a ground water system. Knowledge of flow patterns is necessary to understand and predict the effects of disruption of recharge areas and aquifers or contamination of an aquifer.

Topography, geologic structure, stratigraphic relationships of aquifers and aquicludes, and permeability of the hydrogeologic units control ground water flow. The Rosebud underclay restricts vertical flow and causes lateral flow in the more permeable coal. Because the strata (base of the Rosebud coal) is sloping, flow is generally in the direction of the gradient. North and west of Colstrip the dip is toward the town and mine with a gradient of about 80 feet per mile. Further south the gradient decreases to about 20 feet (Van Voast 1973). East Fork of Armell's Creek and the existing coal mine diverts some of the flow in this aquifer. Other flow is toward Rosebud Creek. Flow in the other coal and sandstone aquifers within 50 feet of the Rosebud seam is probably very similar (Van Voast 1973). Since even the underclays are not completely impermeable, some vertical movement of the ground water does take place. Indications are that flow between aquifers tends to be downward in the vicinity of Colstrip (Van Voast 1973).

3. Ground Water Usage

Local agricultural uses of water heavily depend upon ground water for domestic and stock uses. The town of Colstrip has also been dependent upon this source of water, although this situation will change when the pipeline from the Yellowstone River for Units 1 and 2 is operational.

The wells in the area range from 20 to 350 feet deep and generally yield less than 20 gallons per minute. Four wells supplying the town of Colstrip range in depth from 350 to 1,000 feet and yield up to 40 gallons per minute (Van Voast 1973).

B. Water Quality

Ground water quality in the Colstrip area is being investigated by the USGS and the Montana Bureau of Mines and Geology. Regionally, ground water in the Fort Union formation is of principal concern since this is by far the dominant geological unit supplying ground water in the area. Ground water quality in the Fort Union formation, though highly variable is generally fair to poor. It is hard and is a magnesium sodium-sulfate type with a moderate to high concentration of dissolved minerals. It is expected that Colstrip Units 3 and 4 will not have a significant regional ground water impact, thus, quality of ground water near Colstrip is of principal interest.

Van Voast (1974, p. 7) described the quality of ground water near Colstrip based on data collected by the USGS and the Montana Bureau of Mines and Geology. He states:

> Preliminary interpretations from the data are that ground waters in the Colstrip area are highly varied in degrees of mineralization and in chemical types and in that specific chemical types do not correspond with specific aquifers or locales. In general, the least mineralized waters (less than about 1000 mg/l (milligrams per liter) dissolved solids) are those in which calcium, magnesium, and bicarbonate are the principal constituents. By far the most predominant waters found in the area are those containing the principal constituents, magnesium, calcium, and sulfate. A wide range of dissolved-solids concentrations (about 1000 mg/l to about 5600 mg/l were found for these waters. A third chemical type of ground water, sodium-sulfate water, was found having a dissolved-solids concentration range of about 2000 mg/l to about 3500 mg/l.

Since there were considerable efforts directed at ground water quality near Colstrip, no field investigation of ground water quality was conducted as part of this project. Additional detailed efforts are in progress to further define ground water quality in the area and the impact of mining on quality (Van Voast 1974).

10.1.3.3. Precipitation-Chemistry Analysis

A. On-Site Data Collection

Bulk precipitation was collected in the fall of 1973 (Set 1) from vegetation sampling sites (shown in Figure 10-25, Section 10.1.6.) except NE1, E2, and NW1; and from all 35 vegetation sampling sites in the spring of 1974 (Set 2). The bulk precipitation collection device consisted of a plastic sac fastened to the stem of a plastic funnel, to which a six-inch-long piece of plastic tubing was attached. The funnel was wired into a tin can and the can bolted to a six-foot length of 3/4" angle iron, which was anchored in the ground. One collector was placed at each site. Excepting the three sites noted above, two collections were made per site—one in the early spring, containing the winter's precipitation, and one later in the spring, containing one month's precipitation.

B. Results of Precipitation Chemistry Studies

The pH values of 68 samples of rainwater collections obtained from the 35 sampling sites were measured. Sixty-six of these samples were analyzed for fluoride content and 14 were analyzed for sulfate content. The sample results are shown in Table 10-30. A summary of the results is presented with similar analyses of bulk precipitation collections from Anaconda and East Helena, Montana, and the Mt. Storm area of West Virginia and Maryland in Table 10-31, derived from more than 240 samples from all four areas.

As can be ascertained from the pH values of rainwater from all four areas shown on Table 10-31, only the pH values from the Mt. Storm area

TABLE 10-30

Site #	No. of Data	ppm Average	High	Low
N1				
Precipitation pH	2	6.69	6.72	6.67
Precipitation F^-	2		none detected	
N2				
Precipitation pH	2	6.45	7.22	5.67
Precipitation F^-	2		none detected	
N3				
Precipitation pH	2	6.78	6.96	6.59
Precipitation F^-	2		none detected	
N4				
Precipitation pH	2	7.4	8.00	6.86
Precipitation sulfate	1	9.0	-	-
Precipitation F^-	2		none detected	
NE1				
Precipitation pH	1	6.55	-	-
Precipitation F^-	1		none detected	
NE2				
Precipitation pH	2	7.02	7.12	6.92
Precipitation F^-	2		none detected	
NE3				
Precipitation pH	2	6.62	7.10	6.14
Precipitation F^-	2		none detected	
NE4				
Precipitation pH	2	6.8	7.38	6.15
Precipitation sulfate	1	3.0	-	-
Precipitation F^-			none detected	

TABLE 10-30 (cont.)

Site	No. of Data	ppm		
		Average	High	Low
E1				
Precipitation pH	2	6.32	6.42	6.21
Precipitation F^-	2		none detected	
E2				
Precipitation pH	1	5.96	-	-
Precipitation F^-	1		none detected	
E3				
Precipitation pH	2	6.46	6.98	5.93
Precipitation F^-	2		none detected	
E4				
Precipitation pH	2	5.76	6.33	5.19
Precipitation sulfate	1	4.0	-	-
Precipitation F^-	2		none detected	
E5				
Precipitation pH	2	6.26	6.27	6.25
Precipitation F^-	2		none detected	
SE1				
Precipitation pH	2	7.63	8.10	7.15
Precipitation F^-	2		none detected	
SE2				
Precipitation pH	2	6.19	6.35	6.03
Precipitation F^-	2		none detected	
SE3				
Precipitation pH	2	6.53	6.88	6.18
Precipitation F^-	2		none detected	

TABLE 10-30 (cont.)

Site #	No. of Data	ppm Average	High	Low
SE4				
Precipitation pH	2	6.29	6.43	6.15
Precipitation F⁻	2		none detected	
SE5				
Precipitation pH	2	6.27	6.89	5.64
Precipitation F⁻	2		none detected	
S1				
Precipitation pH	2	5.70	5.82	5.58
Precipitation F⁻	2		none detected	
S2				
Precipitation pH	2	6.70	6.70	6.70
Precipitation F⁻	2		none detected	
S3				
Precipitation pH	2	6.04	6.24	5.83
Precipitation F⁻	2		none detected	
S4				
Precipitation pH	2	6.81	7.39	6.22
Precipitation F⁻	2		none detected	
SW1				
Precipitation pH	2	7.70	7.81	7.58
Precipitation F⁻	2		none detected	
SW2				
Precipitation pH	2	6.39	6.55	6.24
Precipitation F⁻	2		none detected	
SW3				
Precipitation pH	2	6.25	6.68	5.81
Precipitation F⁻	2		none detected	

TABLE 10-30 (cont.)

Site #	No. of Data	ppm		
		Average	High	Low
SW4				
Precipitation pH	3	5.95	6.86	5.27
Precipitation F$^-$	3		none detected	
W1				
Precipitation pH	2	7.73	8.66	6.80
Precipitation F$^-$	2		none detected	
W2				
Precipitation pH	2	6.40	6.56	6.24
Precipitation F$^-$	2		none detected	
W3				
Precipitation pH	2	6.34	6.57	6.10
Precipitation F$^-$	2		none detected	
W4				
Precipitation pH	2	6.47	6.86	6.08
Precipitation F$^-$	2		none detected	
NW1				
Precipitation pH	1	6.55	-	-
Precipitation F$^-$	1		none detected	
NW2				
Precipitation pH	2	6.96	7.45	6.46
Precipitation F$^-$	2		none detected	
NW3				
Precipitation pH	2	6.52	6.81	6.23
Precipitation F$^-$	2		none detected	

TABLE 10-30 (cont.)

Site #	No. of Data	ppm Average	 High	 Low
NW4				
Precipitation pH	2	6.08	6.48	5.68
Precipitation F^-	2		none detected	
NW5				
Precipitation pH	2	6.78	6.85	6.70
Precipitation F^-	2		none detected	

TABLE 10-31

Precipitation Chemistry Summary

	pH		Fluoride (F) ppm		Sulfate ($SO_4=$) ppm	
Colstrip						
average	6.54	68 samples	none detected	66 samples	4.3	14 samples
high	8.66				20	
low	5.19				0	
Anaconda						
average	6.19	54 samples	.04	45 samples	6	19 samples
high	7.67		.19		20	
low	4.75		0		0	
East Helena						
average	6.67	78 samples	.05	43 samples	none analyzed	
high	8.80		.34			
low	4.78		.01			
Mt. Storm						
average	4.78	51 samples	.05	69 samples	4.9	75 samples
high	6.30		.114		10	
low	3.50		.01		.5	

are significantly different from each other. That there is no significant difference between the pH values found in the rainwater collections from East Helena and Anaconda with those from the Colstrip collection sites is explained in Section 1 .1.5. Also discernable from the data in Table 10-31 is that the sulfate levels found in the rainwater collections from all four areas are not significantly different. Section 1 .1.5.2. presents a discussion of the chemical levels in precipitation which cause damage in the form of acid rain. Acid rain predictions specifically related to Colstrip are presented in Section 11.1.5.4.

It is believed that because of the collecting procedures utilized in all four areas as well as the time lapse between rainfall periods and chemical and physical analysis periods, it has not been possible to detect and portray an accurate description of how often and when acid rains are occurring in these areas. With the use of better collecting methods and techniques these shortcomings might be removed from current methods of precipitation chemistry studies.

10.1.4. Geology

Man's relationship with the earth is varied and complex. Technological man depends upon the earth for materials which he converts into useful objects or energy. Man's activities are also affected by earthquakes, volcanos, mudslides, floods, and other natural phenomena. The builders of power plants must consider the local conditions and processes of the earth to ensure reasonable success in their venture.

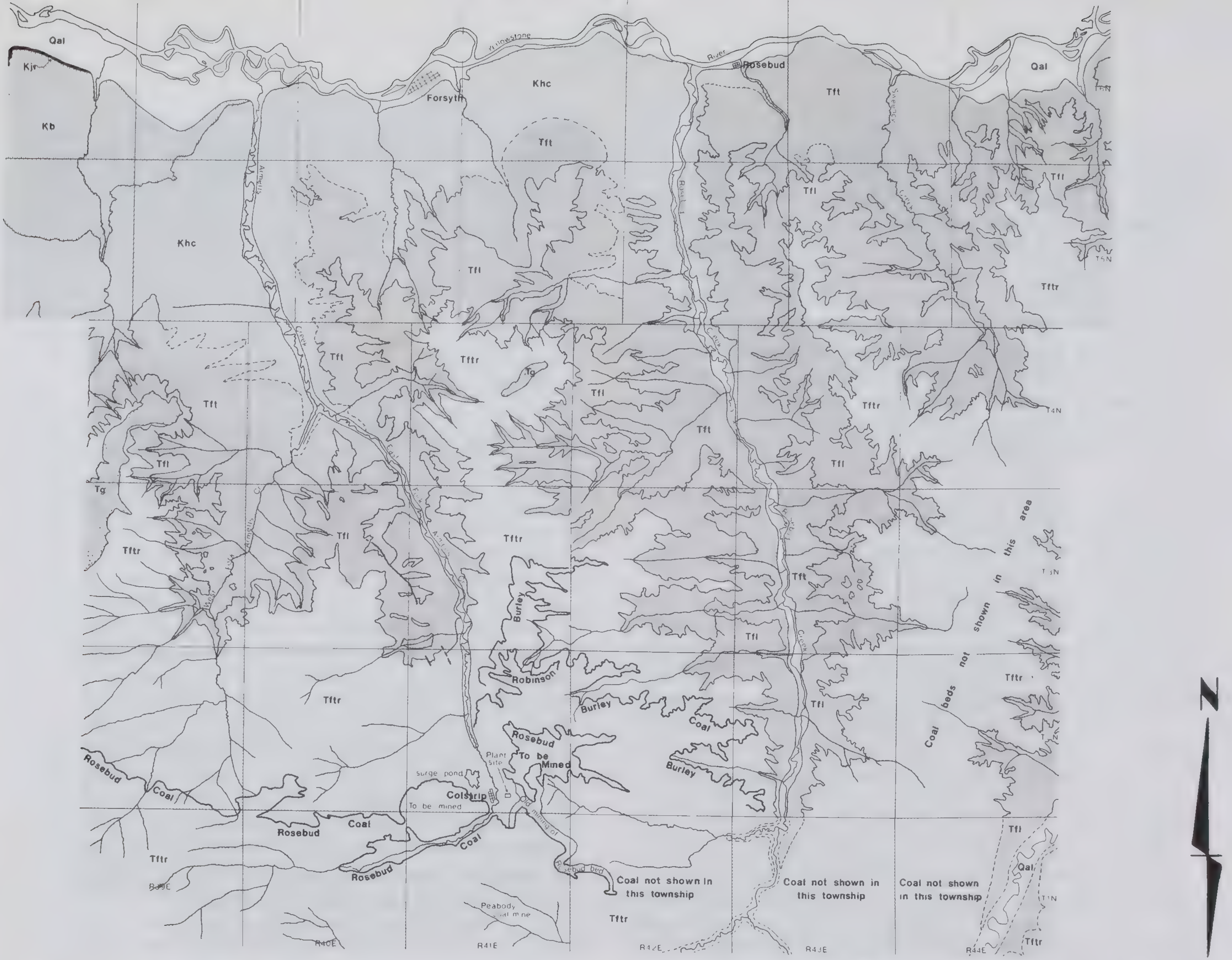
Many geologic processes are localized, though others, such as earthquakes, affect large areas. The area shown on Figure 10-19 is much smaller than that otherwise studied in this report. By limiting the area, a larger-scale map can be used to illustrate the geologic setting near the plant site.

The limits of the geology study area are the boundaries of Rosebud County on the east and west, the Yellowstone River to the north, and the Montana base line to the south (see Figure 10-19).

10.1.4.1. Physiography

The study area lies within the unglaciated Missouri Plateau, a division of Fenneman's (1931) Great Plains Province. The area is within the structural depression known as the Powder River Basin which lies between the Black Hills uplift to the southeast and the Big Horn uplift to the west (this area is not the drainage basin of the Powder River). The Fort Union Formation, which contains much of the valuable coal of eastern Montana, lends its name to the region where it is the bedrock (Ayler et al., 1969).

The study area is drained by the Yellowstone River and its tributaries. Armells Creek,



GEOLOGY

NOTE: No attempt was made to resolve difference between maps which occur between R 41E and R 42E. Extensive gravel deposits mapped by Pierce are not shown on this map. Only coal beds of importance to this project are shown.

LEGEND

Qal	Alluvium
Tg	High Level Terrace Gravels (west half only)
Tftr	Fort Union Fm Tongue River mem
Tfl	Fort Union Fm Lebo mem
Tft	Fort Union Fm Tullock mem
Khc	Hell Creek Fm
Kb	Bearpaw Fm
Kjr	Judith River
⌒	Limit of Coal Bed (Name of bed shown on side underlain by coal)
---	Fault Line

Sources:
Dobbin 1929, Pierce 1936
and Renick 1929

0 1 2 3 4 8 Miles

FIGURE 10-19

Rosebud Creek, and the Tongue River are the principle streams in the area. Colstrip lies along the East Fork of Armells Creek. Only the Yellowstone River, Tongue River, and parts of Rosebud Creek are considered perennial streams, though only the Yellowstone has never been dry.

Even though the area is part of the Great Plains, it has considerable relief. Elevations range from 2435 feet on the Yellowstone River in the northeast corner of the study area to about 4800 feet in the Little Wolf Mountains west of Colstrip, a difference of almost 2400 feet. Local relief, though, seldom exceeds 300 feet.

The area consists of dissected uplands (which constitute the divides between the major streams), the stream valleys, and a number of terraces which range in elevation from a few feet above the bed of the Yellowstone River to more than 1000 feet. The terraces are commonly capped with gravel containing rounded pebbles and boulders and are believed to be relic beds of the Yellowstone or ancestral rivers before they had cut to the present level of the Yellowstone (Dobbin 1929). The ages of these terraces are uncertain. The highest (and therefore oldest) may be Pliocene or Miocene in age (Dobbin 1929 and Pierce 1936).

The landscape is developed upon nearly horizontal sedimentary strata. Outcrops of sandstone and clinker produce cliffs, knobs, hills, and similar features. Shale, because it is less resistant to erosion, forms gentle slopes, badlands, and rolling surfaces. Hogbacks are not found in the study area because the strata are not tilted to the degree necessary for their formation. Some level surfaces, for example some high surfaces in the Little Wolf Mountains, are protected by sandstone or clinker which act as cap rocks.

10.1.4.2. Historic Setting of Study Area

A thick sequence of sedimentary strata ranging in age from Cambrian to Paleocene underlies Colstrip (see Section 10.1.4.3., Stratigraphy). Sedimentary rocks are the residue of ancient environments. The rocks and their relationships to each other, can be used to decipher the nature and sequence of ancient environments (i.e. earth history). However, only certain characteristics of ancient environments are recorded by their residue and some environments left no record at all. The following interpretations emerge from a study of the rocks.

Through the Paleozoic and Mesozoic eras, the study area was covered by seas at times and exposed to erosion at others. Streams sometimes eroded older rocks and sometimes deposited new sediments. Over hundreds of millions of years, sedimentary rocks accumulated. Toward the end of the Mesozoic, the Rocky Mountains were uplifted to the west, and the seas withdrew from eastern Montana for the last time. Streams draining the uplifted mountains carried sediment into the study area during late Cretaceous and Paleocene time. A vast lowland consisting of stream channels, fresh water lakes, and swamps covered the area. Vegetation filled many of the swamps and wet areas, which gave rise to numerous coal deposits occurring in the Hell Creek and Fort Union formations. How long this period of sedimentation lasted in the study area is not known, for at some point, the streams began to erode the youngest deposits. Any Eocene or Oligocene sediments that may have been deposited are now gone. There are, however, deposits of the downcutting streams occurring upon the terraces found in the area. Deposition is still locally taking place along the streams. (For relationships of various geologic ages see table at end of glossary.)

10.1.4.3. Stratigraphy

A. Unexposed Strata

A well, drilled to determine the feasibility of using groundwater for the generating complex at Colstrip, penetrated 9336 feet of sedimentary rocks. The oldest strata reached by the well was the Winnipeg formation (Ordovician). Figure 10-20 shows the stratigraphy at Colstrip as revealed by the well log. The Deadwood formation and Precambrian basement rocks were not penetrated but are believed to exist as they appear in the figure.

1. Paleozoic Rocks

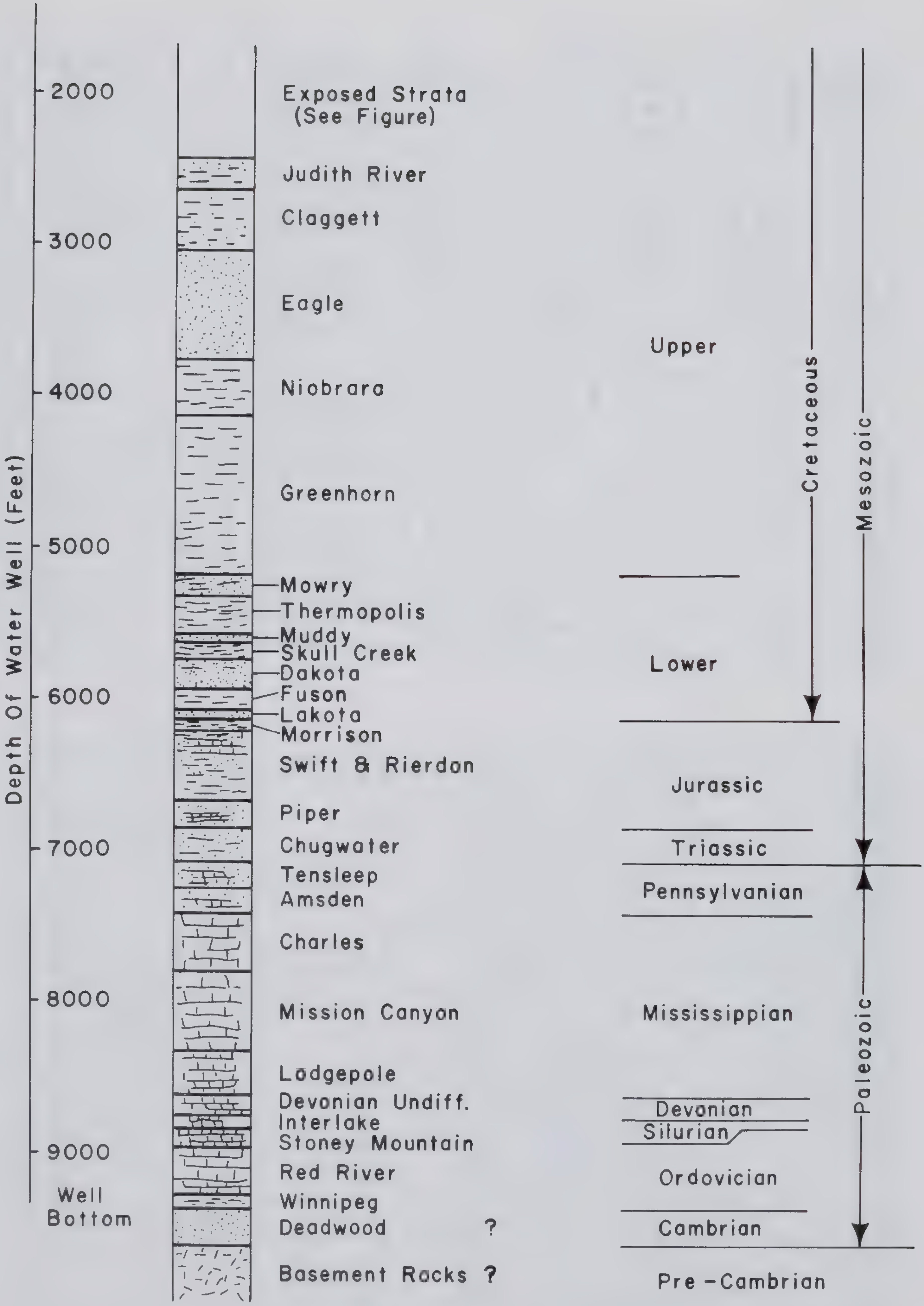
The lower Paleozoic is represented by several thin formations in the Colstrip area, consisting largely of limestone, dolomites, and evaporite deposits. The Mississippian carbonates occur or once occurred over all or almost all of Montana and over vast areas in adjacent states. These marine limestones are resistant to erosion and often form cliffs, peaks, and mountains where exposed. Extensive portions of the Black Hills and Big Horn mountains on either side of the Powder River Basin owe their physiographic features to these limestones.

Several unconformities exist in the Paleozoic section, a major one occurring at the top of the Mississippian limestone. The sea which produced the thick body of Mississippian carbonates retreated, and when it returned in the Pennsylvanian it deposited more sandstone and shale than limestone. The vast and prolonged carbonate environments of the Mississippian have never been repeated in southeastern Montana.

2. Mesozoic Rocks

The Triassic and Jurassic portions of the column, separated by an unconformity, are composed of several formations of partly marine and mostly clastic rocks.

About half of the total thickness of sediments underlying Colstrip are of Cretaceous age;



UNEXPOSED STRATA AT COLSTRIP
(Mostly From Drillers Log Of Water Well At Colstrip)

Figure 10-20

mostly Upper Cretaceous. The Lower Cretaceous consists of a number of thin sandstone and shale formations but thick units of mostly marine shale, siltstone, and sandstone constitute the remainder of the Cretaceous section. The Bearpaw formation (described below) is the last marine unit in eastern Montana.

B. Exposed Strata
(see Figure 10-21)

1. Judith River Formation

The Judith River formation crops out along the Yellowstone River in the northwest corner of the area. Its areal extent in the study area is limited to about one square mile adjacent to the river floodplain.

The top of this formation is composed of about 20 feet of hard grayish-white sandstone which is more resistant than adjacent strata. Beneath the sandstone, the formation consists of 150 feet of a brown sandy shale. Fossilized marine invertebrates are evidence for a marine origin of this formation (Dobbin 1929).

2. Bearpaw Shale

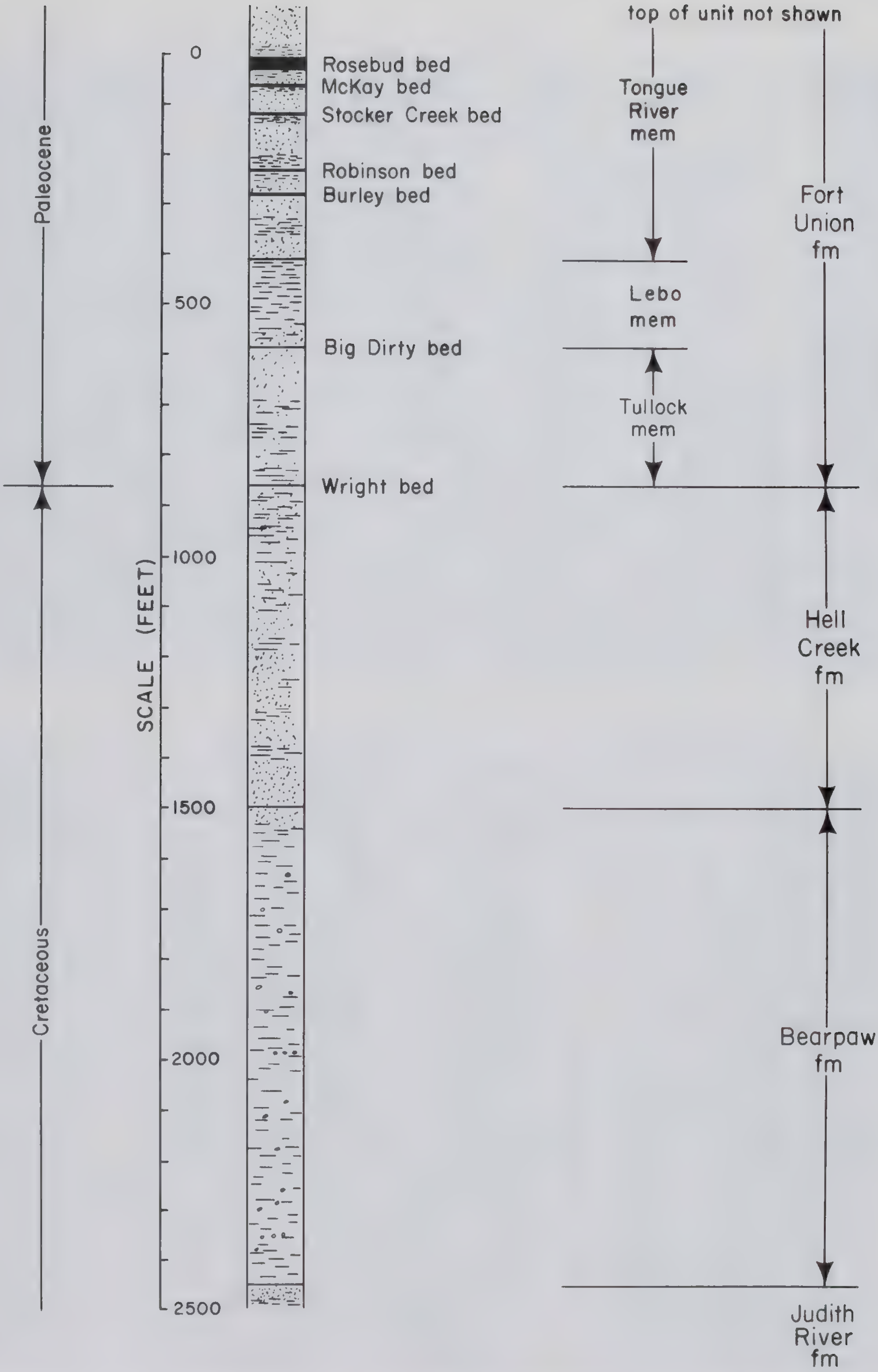
This formation, about 950 feet thick, is composed mostly of a dark gray to chocolate-colored fossiliferous marine shale. The top of this interval is a transitional zone 20 to 60 feet thick believed to be the youngest marine sediments in Montana (Dobbin 1929 and Renick 1929). The shale contains abundant calcareous concretions, some of which contain marine invertebrate fossils (Dobbin 1929).

3. Hell Creek Formation

The name "Hell Creek" was once applied to a member of the Lance formation. In the study area, the Lance was considered to be Tertiary in age and was divided into the Hell Creek and Tullock members (Dobbin 1929). The name "Lance" is little used at present in Montana and the Hell Creek unit is considered to be a separate formation of Cretaceous age (Kepferle 1954).

The Hell Creek, about 636 feet thick in the study area, lies conformably and without a sharp contact on the Bearpaw shale. Grayish-brown, crossbedded sandstone beds, some more than 50 feet thick, occur in this formation. Somber-colored clay and shale also occur in the Hell Creek in the study area but not as abundantly as at the type section in Garfield County. These shales are less yellow in color than the overlying Fort Union sediments (Dobbin 1929).

Areas where the Hell Creek crops out tend to be rugged, and access is difficult. A few badlands occur along Armells Creek and other streams in the study area, and some unique forms are produced by wind erosion in some of the beds of this unit. Cross-bedded conglomerate layers in the lower part of the Hell Creek contain pebbles more than an inch in diameter. These conglomerates suggest the presence of stronger currents



GENERALIZED STRATIGRAPHIC COLUMN OF EXPOSED STRATA IN STUDY AREA

Figure 10-21

than those which deposited the upper portions of the formation. The upper part of the unit is composed mostly of light-colored sandy shale with lenses of sandstone and some concretionary beds. The top of Hell Creek is drawn at the Wright coal bed. Except for the Wright coal, the contact between the Hell Creek and Fort Union formations would be difficult to establish (Dobbin 1929).

4. Fort Union Formation

Above the Wright coal bed, there is a sequence of sandstones, shale, clay, and coal of Paleocene age referred to as the Fort Union formation. Three members are recognized within the formation -- the Tullock, the Lebo, and the Tongue River. The Tullock member was once included in the Lance formation. The Fort Union attains a thickness of about 2,175 feet in Rosebud County (Kepferle 1954).

a. Tullock Member

The Tullock member consists of the yellowish-gray sandstone, sandy shale, and thin coal beds between the Wright coal bed at its base and the Big Dirty coal bed or a resistant, calcareous, sandstone rimrock at the top. In places where neither the Big Dirty coal nor the sandstone bed is present, the contact between the Tullock member and the overlying Lebo shale is indefinite. The thickness of this member is 240 to 300 feet in the study area (Kepferle 1954).

b. Lebo Member

The Lebo member is composed of dark gray to black clay and shale, concretion zones, and several thin coal beds. In places, nonpersistent sandstone lenses occur. The thickness of this member ranges from 105 feet to about 220 feet in the study area, averaging about 170 feet (Kepferle 1954). In valleys where it crops out, this member tends to form badlands and supports little vegetation.

c. Tongue River Member

The uppermost portion of the Fort Union formation is the Tongue River member. The base of the Tongue River is marked by a transition zone from the sandy shale of the Lebo to the predominantly light-colored sandstone and shale of the Tongue River. Although the top of this member has been eroded away, about 1,600 feet of it remain near the southern edge of the study area (Kepferle 1954).

This member contains sandstone, shale, carbonaceous shale, some thin fresh-water limestone beds, and coal. Several of the coal beds are thick enough to be commercial.

Many of the thicker coal beds have burned along their outcrops. This burning had mostly occurred prior to the arrival of the white man in this area and is presumed to have been caused by wild fires, lightning, and other natural causes.

The process of natural underground coal fires is not well understood, but the burning eventually stops, possibly when oxygen can no longer reach the combustion zone. The heat released during combustion physically (and chemically) alters the sedimentary rocks around the coal, especially above the seam. The thermally metamorphosed rocks generally have an orange or red color and are called clinker or, incorrectly, scoria. Part of this clinker was fused but the greater amount retains its sedimentary texture. Clinker is a brittle, highly fractured rock which is more resistant to erosion than most of the unaltered rock. Therefore, within the area of the thicker coal beds, much of the surface is capped by clinker and some of the landforms are the result of this material.

5. Terrace Gravels and Alluvium

As many as 13 different levels of terrace gravels, some of which are 70 feet thick, lie along the Yellowstone River in the study area. These gravels are thought to be from Cligocene to Recent in age (Kepferle 1954). They contain boulders up to a foot in diameter, though most are one to four inches, and include igneous rocks, quartzite, limestone, and clinker. In places, the gravels are cemented. The highest of these deposits are 1,000 to 1,100 feet above the present level of the Yellowstone River. Other deposits, thought to be Miocene or Pliocene in age, occur about 700 feet above the river (Kepferle 1954).

The floodplains of the Yellowstone River and the major streams in the study area are generally covered by alluvium, consisting mostly of silt, clay, sand, and varying amounts of gravel.

10.1.4.4. Structure

The study area lies in a broad shallow syncline between the Big Horn uplift to the west, the Porcupine uplift to the north, and the Black Hills uplift farther to the east. Over most of the area the beds are essentially flat-lying with dips of about one degree or less. The greatest dip, about three degrees to the south, is in the northwest corner of the study area where the Judith River and Bearpaw formations crop out. This dip is a reflection of the Porcupine uplift. The regional dip in the entire study area is also to the south (Dobbin 1929).

Minor flexures of the beds do occur throughout the basin; however, these are gentle folds with small changes in dip (Dobbin 1929). Some minor differences in the elevations of coal beds could be the result of differential compaction. Thick coal beds, such as those occurring in the Fort Union formation, are derived from much greater thicknesses of organic material originally deposited. A stratum, originally horizontal, overlying a thick coal seam in one area and thick sandstone in another area would be warped by the greater compaction of the coal.

Some normal faults exist in the study area which have displacements of about 60 feet (Dobbin 1929). Other small faults have been mapped by the USGS to the west of Colstrip in an area to be mined. Pierce (1936) suggests these faults may be due to differential compaction of the underlying sediments.

10.1.4.5. Economic Geology

A. Coal

The subbituminous and lignite deposits of Montana, Wyoming, and the Dakotas represent one of the largest coal deposits in the world. Although the coal within the study area is but a small fraction of the deposits in the four state area, it is the study area's most economically important mineral commodity. This situation is likely to exist for some time unless major new discoveries of other minerals are made or coal should lose its present economic status. The recent shortages of petroleum products, the hazards of dependence upon foreign sources of oil, and the recent changes in federal policy regarding increased reliance upon coal will, no doubt, maintain or increase the value of Montana coal for many years to come.

Although numerous coal beds exist in the older units, the Tongue River member of the Fort Union formation contains the only commercial coals. The Wright bed occurs at the base of the Tullock member of the Fort Union formation, and has been mined in the past to supply local needs in Forsyth (Dobbin 1929). Where it was mined, this bed ranges from three to four feet in thickness. Along Armells Creek it ranges from a foot or less to about three feet in thickness and in places it splits into two seams several feet apart (Dobbin 1929).

The Hambre bed occurs about 200 feet above the Wright in the Tullock member and consists of an average of three feet of coal, carbonaceous shale, and carbonaceous sandstone.

The Lebo member contains at its base the Big Dirty bed, which ranges in thickness from 3 to 13 feet but usually consists of only a small amount of clean coal (Dobbin 1929).

None of these beds occurring in the Tullock and Lebo members are economical coal deposits by today's standards.

The Burley bed occurs about 130 feet above the base of the Tongue River member and is from two to ten feet thick (Pierce 1936). North of Colstrip, along the East Fork of Armells Creek, the average thickness is about four feet (Dobbin 1929). The Burley bed constitutes a potentially economical resource in the area north of Colstrip, although the Department knows of no plans to mine this bed.

Near Colstrip, the Robinson bed lies about 43 feet above the Burley and is up to eight feet thick (Dobbin 1929). In the Rosebud coal field (east of R41E), the Turret bed occurs at about the same horizon as the Robinson bed. The Turret thickens to the east from less than 18 inches west of Rosebud Creek to an average of 12 feet along the Rosebud-Tongue River Divide (Pierce 1936).

West of Colstrip, the Stocker Creek bed crops out about 130 feet above the Robinson bed. Maximum thickness of this bed was reported by Dobbin (1929) to be nine feet just west of the study area.

The Rosebud bed lies about 360 feet above the base of the Tongue River member (Dobbin 1929 and Kepferle 1954) and is the thickest and most widespread coal bed in the study area (Figure 10-22), averaging about 25 feet thick and nearly 30 feet thick in places (Matson and Blumer 1973). Matson and Blumer (1973) indicate strippable reserves (under less than 150 feet of overburden) of the Rosebud bed near Colstrip to be 1,439 million tons.

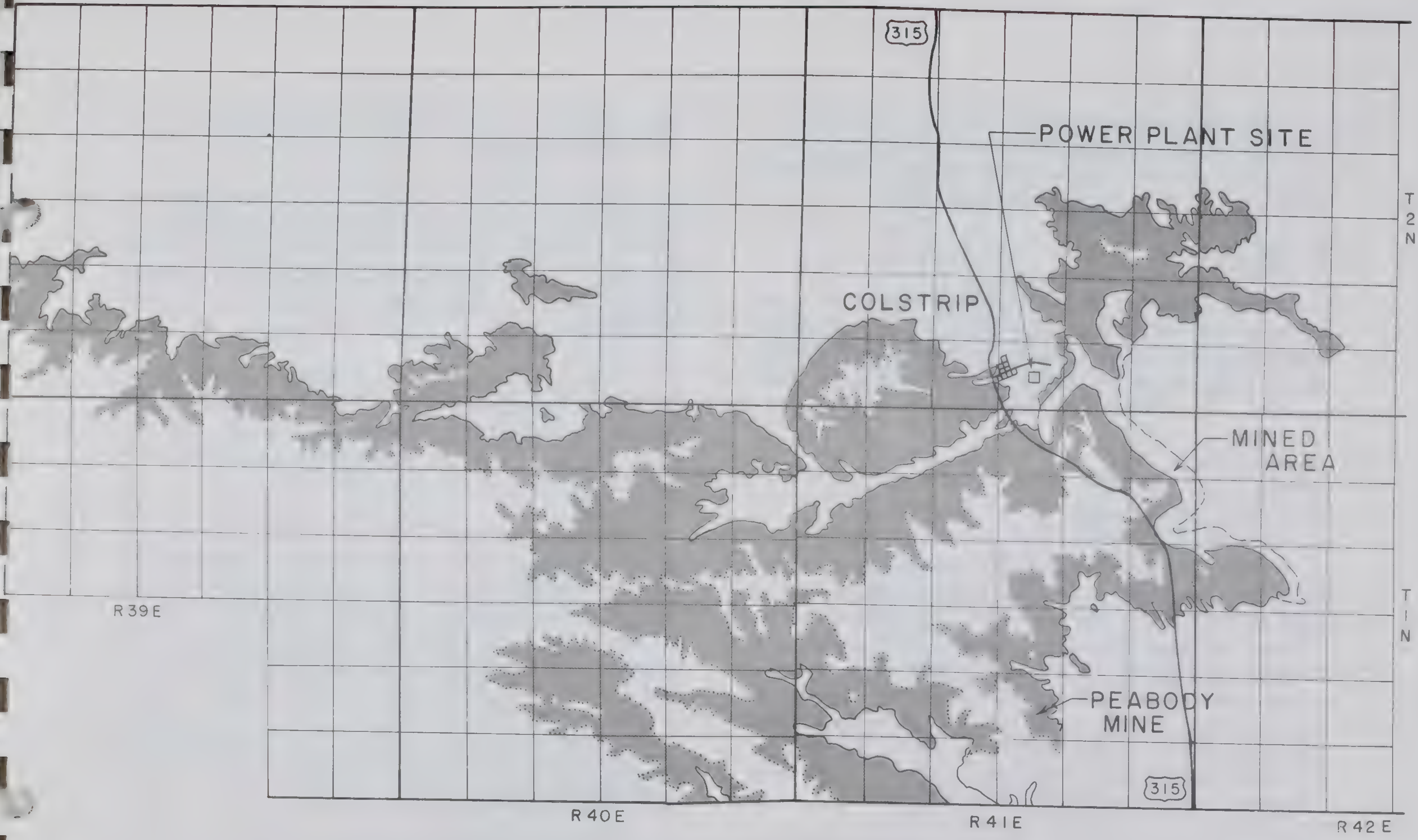
The McKay bed lies about 19 feet below the Rosebud and averages about eight feet thick. McKay coal is of lower quality; however, it remains an economic resource with perhaps 500 million tons in reserve if one assumes this bed can be mined with the Rosebud.

Together, the Rosebud and McKay seams constitute the area's most valuable coal.

Strip mining of the Rosebud seam at Colstrip began in 1924, to supply steam locomotives on the Northern Pacific Railroad. Mining continued until the 1950's when steam engines were phased out. Western Energy Company, a subsidiary of MPC, bought the town, mining equipment, and leases and renewed mining in 1968.

Since 1968, this mine has supplied MPC's 180-megawatt Corrette plant in Billings and some eastern utilities. By 1972, production was up to 5.5 million tons. Although sales were smaller in 1973 and 1974, the company expects to produce 7.2 million tons in 1975 and up to 19.3 million tons by 1980. Part of this production will fire those power plants built at Colstrip. All past production in this mine has been from the Rosebud seam, but McKay coal may be taken in the future in compliance with the Montana Coal Conservation Act of 1973.

Peabody's Big Sky Mine, which opened in 1969 just south of Colstrip produces from both the Rosebud and McKay seams. This company expects to remove 2.5-4.0 million tons in 1975. All of this coal will be shipped out of Montana.



COLSTRIP COAL DEPOSIT—ROSEBUD SEAM
(MATSON & BLUMER 1973)

- Limit of Rosebud
- 150 Ft. Overburden Limit

FIGURE 10-22

Several other coal beds lie above the Rosebud but have much less economic importance than the Rosebud within the study area. These beds occur south of the Rosebud outcrop.

B. Clinker

The clinker which occurs in the study area is used locally for railroad ballast and road-surfacing material. Small quarries are worked from time to time to extract this material when needed.

10.1.4.6. Seismicity

Destructive earthquakes are dramatic examples of a dynamic geologic process. Whole cities and thousands of persons have perished in large shocks, making earthquakes among the most feared natural phenomena. Although thousands of tremors occur each year, most are too small or remote to be destructive. Since the 1860's, more than 1000 earthquakes have occurred in Montana, but only a few caused extensive damage (Scott 1936 and Stewart et al. 1964).

Montana lies in the intermountain seismic belt, one of the more active earthquake zones in the United States (Smith and Sbar 1974). Large quakes can disable electrical generating plants by damaging the plant itself or its associated facilities. Therefore, seismic hazards should be evaluated and considered in the planning of the proposed facilities.

The San Fernando, California, earthquake of 1971 (magnitude 6.4) caused $25 million damage to power systems, including damage to thirty transmission towers ($160,000), one D.C. converter ($20 million), and transmission substations (Palk and Hanson 1973).

Causes of earthquakes include man-made explosions, cave-in's, rockfalls, volcanic explosions and meteorite impacts. Nearly all destructive shocks, however, are caused by sudden movement along faults (Fraser 1964).

Relative motion of parts of the earth's crust stresses the boundaries of these areas. Rock strength and friction prevent continuous motion. The shearing stresses produce an elastic strain which is released along a fault when the stress overcomes the strength of the rock. The energy of the suddenly released strain is converted into movement along the fault and is propagated as seismic waves. An area experiences an earthquake as the seismic waves vibrate the ground in passing (Howell 1959).

Earthquake intensity is a qualitative indicator of the violence of a quake as determined by its effect upon people and man-made structures, and by visible changes it causes in the earth. The Modified Mercalli scale (Table 10-32) is used to express intensity.

Table 10- 32

MODIFIED MERCALLI INTENSITY SCALE

I. Not felt except by a very few under especially favorable circumstances.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing truck. Duration estimated.

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, and doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably.

V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving motorcars.

VIII. Damage slight in specially designed structures; considerable in ordinary buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed.

IX. Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI. Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

(From Coffman and vonHake 1973)

Magnitude (measured by the Richter scale) is a logarithmic measure of the energy released by a quake. Maximum intensity and magnitude correlate only roughly because they evaluate different properties (Table 10-33). This correlation is particularly weak when earthquakes of different depths are compared. Shocks of magnitude 5.0 or below generally do not cause great damage.

Table 10-33

MAXIMUM INTENSITY AS RELATED TO MAGNITUDE OF SHALLOW EARTHQUAKES.

MAGNITUDE (Richter Scale)	INTENSITY (Modified Mercalli Scale)
2	I - II
3	II - IV
4	IV - VI
5	VI - VII
6	VII - IX
7	IX - X
8	X - XI
8.5	XI - XII

Earthquakes are not distributed randomly in either space or time. Certain parts of the world and parts of Montana are more seismically active than others. Also, at a given location, significantly more earthquake activity may occur in one period of time than in some other equally long period.

Temporal earthquake distribution patterns in Montana before the 1860's are unknown, since no earlier records exist. Accurate instrumental records exist for an even shorter period of time. Spatial distribution patterns can be only poorly estimated from the presence of large faults and fault scarps and from some understanding of the geologic setting of Montana. The distribution of pre-1860 earthquakes showing no surface manifestations is unknown. Much of any prediction of earthquake activity through the next 50 to 100 years is based upon the events of the past century which is only a moment of geologic time.

Most known Montana earthquakes, including all the major ones, have occurred west of the plains in the northern Rocky Mountain province (Coffman and vonHake 1973). This area is within the intermountain seismic belt, a broad zone of earthquake epicenters extending from northwestern Montana through the Helena area, southward through West Yellowstone, southeastern Idaho, and central Utah to southwestern Utah (Smith and Sbar 1974). Outside of California and Nevada, this zone is the most active seismic region in the conterminous United States (Figure 10-23).

Within Montana, four areas have been particularly active since the 1860's: 1) Helena vicinity, 2) Three Forks area, 3) Flathead Lake area, and 4) Hebgen Lake area. Major shocks (intensity VII or greater) which have occurred are shown in Table 10- 34.

Earthquakes seldom occur singly. Two patterns of occurrence predominate:1) one main shock followed by numerous smaller aftershocks and 2) a series of tremors (swarm) without any one outstanding shock. The Hebgen Lake earthquake is an example of the first type. There was one main shock, not proceeded by a foreshock but with hundreds of less intense aftershocks which continued for months. On the other hand, the Helena shocks occurred as a swarm with numerous quakes happening prior to and after the strongest ones (Scott 1936 and Murphy et al. 1964).

Colstrip lies well outside of the intermountain seismic belt. Although Colstrip and several other places in eastern Montana have been epicenters of earthquakes, only one shock (in northeastern Montana) was strong enough to cause damage (Crosby et al. 1973; Coffman and vonHake 1973). Large earthquakes occurring in western Montana, especially the Hebgen Lake shock of 1959, have been felt in eastern Montana, but no damage resulted from these shocks in the Colstrip area.

Earthquake hazard evaluation is partly earthquake prediction and partly an evaluation of local response to an earthquake. Damage may result from the earth vibrations alone or from secondary events such as landslides. Table 10-35 is a list of earthquake-related hazards.

Although small local earthquakes and large distant ones may be felt, it seems unlikely that a destructive shock may occur near Colstrip. Even

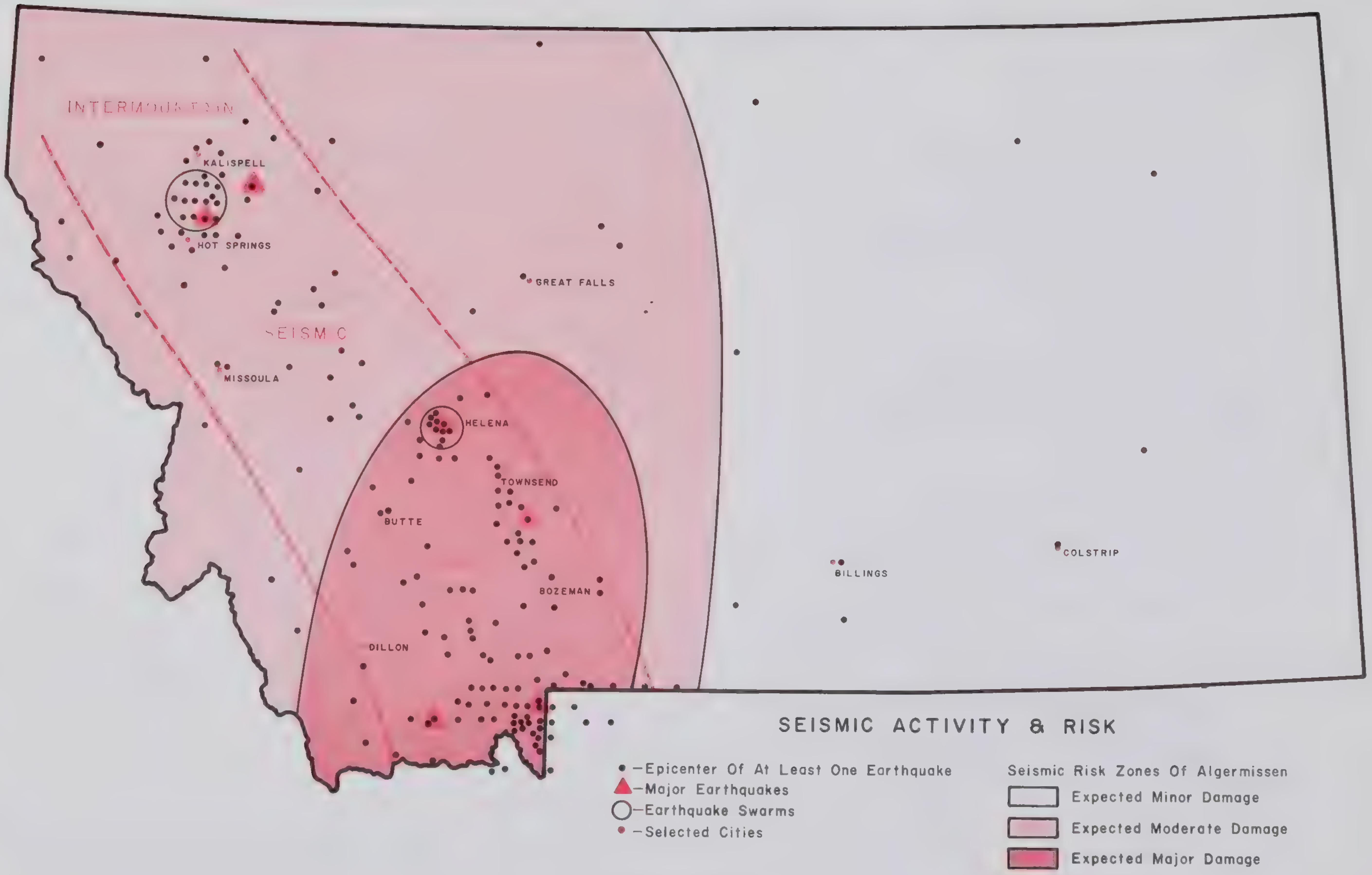

INTERMOUNTAIN
SEISMIC
KALISPELL
HOT SPRINGS
GREAT FALLS
MISSOULA
HELENA
TOWNSEND
BUTTE
BOZEMAN
DILLON
BILLINGS
COLSTRIP
SEISMIC ACTIVITY & RISK
● –Epicenter Of At Least One Earthquake
▲ –Major Earthquakes
○ –Earthquake Swarms
• –Selected Cities
Seismic Risk Zones Of Algermissen
☐ Expected Minor Damage
▨ Expected Moderate Damage
■ Expected Major Damage

FIGURE 10-23

TABLE 10-34

MAJOR MONTANA EARTHQUAKES

Date	Location	Intensity (Modified Mercalli) Scale	Remarks
27 June 1925	Three Forks	VIII	Many buildings damaged, rock slide blocked Lombard RR tunnel.
12 Oct. 1935	Helena	VII	A few structures damages.
18 Oct. 1935	Helena	VIII	Strongest of series — many buildings damaged or destroyed including new high school two dead.
31 Oct. 1935	Helena	VIII	Two dead, additional damage to many buildings
23 Nov. 1947	S. Madison Co.	VIII	A number of buildings damages
31 Mar. 1952	Flathead Lake Area	VII	Wells cracked and chimneys fell
17 Aug. 1959	Hebgen Lake	X	Strongest shock recorded in Montana; buildings destroyed, roads offset, shoreline of Hebgen Lake altered, 23 dead. Waterwells as far away as Florida affected.
1 April 1969	Flathead Lake Area	VII	Damaged chimneys, windows, and a few structures.

TABLE 10-35

EARTHQUAKE DAMAGING EFFECTS

PRIMARY CAUSES	CONTRIBUTING FACTORS	DAMAGING EFFECTS	EXAMPLES
I. Earth Vibration (vertical & horizontal Accelerations)	1. None	Structures damaged	(all large earthquakes)
	2. Unconsolidated rock or man-made fill amplifying earth vibrations	Structures damaged	Greater structural damage in mined areas during Helena earthquakes of 1935
	3. Unstable or thixotropic material	Ground breakage and mass movement	Anchorage, Alaska in 1964
	4. Unstable slope	Landslides, mudslides	Madison canyon slide in 17 Aug 59 earthquake
	5. Loose rocks on steep slopes	Rock fall	Closure of Lombard RR Tunnel in 1925 earthquake
	6. Existing bodies of water	Flooding by seiche waves, tsunami, dam failure, stream blockage, etc.	Creation of Quake Lake in 17 Aug 59 earthquake, waves in Mississippi River during Missouri quakes of 1811-1812
II. Earth surface breakage	7. Reactivation of surface faults	Damages roads and structures built over the break	Roads damaged in 17 Aug 59 earthquake

(Coffman and vonHake 1973)

less likely is ground breakage which would damage the plant. The absence of nearby steep slopes and large bodies of water results in little danger from mass movement or flooding. The consolidated Ronge River rocks are not thixotropic or likely to amplify ground motion. Therefore, the proposed plant site has minimal earthquake risk, and no damage to the plant is likely to occur as a result of earthquake.

10.1.5. Soil

The main impact of power plant units upon the soil of the Colstrip area is the emission of chemicals. Other minor effects of the power plants are the erosion and sedimentation problems that may arise from construction of the plant complex and water supply pipe line.

During the construction period some sedimentation of Armells Creek may occur. The watershed of Armells Creek has steep escarpments, bare stream bottoms, the town of Colstrip, a large mined area and a small acreage of dry land agriculture and summer fallow within its boundaries. All of these conditions add large amounts of sediment to the stream.

The impacts of emission and erosion cannot be assessed without an understanding of the soil characteristics of the landscape. The landform inventory technique used in this study, based on the Ecoclass System developed by the U.S. Forest Service (Ecosystem Task Force 1973), recognized that distribution of soils is determined by factors of climate, physiography, native vegetation, and the source of the of the parent material (Soil Survey Staff 1973). The physiographic features of the study area were divided into four major units which were then subdivided into various soil characteristics as follows:

Soils of the Mountains #1

1. Soils developing in material weathered from noncalcareous consolidated rocks other than granites on very steep or steep mountain slopes with significant outcroppings of rock; in material weathered from permeable limestone bedrocks on steep or very steep mountain slopes, with areas of rock outcroppings.

Soils of the Foothills #1

1. Soils developing in loamy material weathered from folded, consolidated sedimentary and basic igneous rocks on hilly to steep uplands and steep lower valley sideslopes.

Soils of the Plains #1-6

1. Soils developing in sandy to clayey material weathered from sandstones and shales on nearly level benches.
2. Soils developing in clayey material weathered from shales on undulating to steep uplands.
3. Soils developing in loamy to clayey material weathered from shales on steep to very steep highly dissected badlands.

5. Soils developing in clayey and loamy material weathered from interbedded unconsolidated and consolidated sediments on well dissected uplands, narrow level ridgetops and steep valley sideslopes.

6. Soils developing on clayey material weathered from interbedded steeply dipping consolidated and unconsolidated sedimentary rocks.

Soils of the Alluvial Lands (Floodplains) #1

1. Soils developing in highly stratified alluvial deposits on stream floodplains and low terraces.

The above units are presented on the study area map entitled "General Soils" located in Appendix C1. Each map unit contains a series of numbers which correspond to detailed soil association and soil series data presented in tabular form in Appendix C1. The impact parameters (percentage of coarse fragments, depth to bedrock, pH, fertility, shrink/swell, and tilth) are listed for each soil series when data is available. A short discussion of the sources and the process used to create the map is also presented.

In order to provide baseline data on chemical composition of study area soils, analyses were performed on soil samples collected at vegetation sampling sites shown in Figure 10-28 in Section 10.1.6. These data include analysis of 22 elements and pH determinations and are presented in Appendix C2.

10.1.6. Vegetation

Vegetation diversity within the study area results from a variety of topography, soils, climate, and past history of land use. Elevation ranges from approximately 7,500 ft. in the southwestern corner of the study area to approximately 2,500 ft. in the Colstrip area. The average elevation is between 3,000 and 4,000 ft. The Big Horn Mountains, which include the highest elevation in the study area, receive from 20 to greater than 30 inches of precipitation annually. The northern half of the study area is mostly within the 10-14" precipitation zone while the southern half is mainly within the 14-20" precipitation zone. In the Hardin area and along the Tongue and Powder rivers, precipitation is generally between 10-14" annually.

These elevational and climatic gradients result in the kinds of vegetation that dominate the landscape. In the lower elevations and precipitation zones, riparian, sagebrush-grass, and grassland communities usually dominate. Coniferous forest and shrub communities usually dominate the higher elevations and precipitation zones. An area view of the categorization of vegetation into communities, such as those stated above, is sufficient for regional interpretations but not adequate for site-specific interpretations. Categorization by major dominant species of the vegetation types will better serve to evaluate the possible effects of phytotoxins.

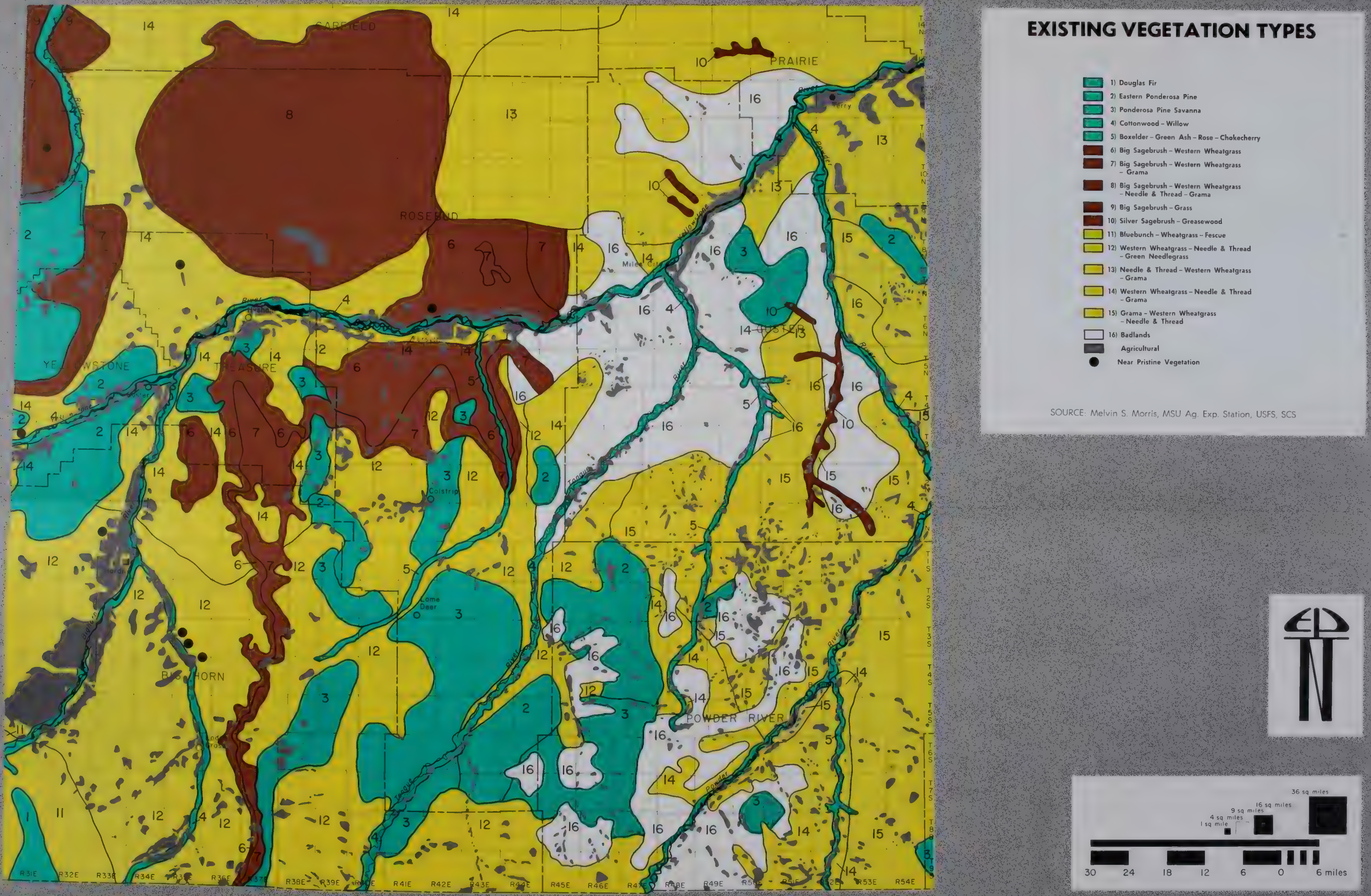
10.1.6.1. Vegetation Types

The study area has 16 vegetation types. These types, arranged according to life form and approximate elevational gradient in Appendix D3, are primarily perennial indigenous dominant species. Introduced annuals and perennial species also occur within the study area because of invasion from tame pastures and roadways.

All study area vegetation types are listed in Appendix D3, but only those that need further clarification or are "critical" in terms of impact will be discussed in the following paragraphs. All types also appear on the accompanying Vegetation Types Map. Figure 10-24 is a generalized portrayal of vegetation in the study area.

The eastern ponderosa pine type (Only common names will be used to identify plants throughout this section. Scientific names of all mentioned species are listed in Appendix D2.) occurs mainly on the Hell Creek geologic formation. It is found in scattered, continuous stands in the southern part of the study area, mostly south of Colstrip, and in the Pine Ridge area south of the Yellowstone River and west of the Big Horn River. Denser stands occur on north, east, and northeast aspects. Rocky Mountain juniper may be associated with ponderosa pine, especially on the poorer, droughty soils of the shaley breaks. Other common associates are shown in Appendix D3.

The ponderosa pine savanna type is a mixture of scattered pine trees and grassland. This is not a true savanna, but, with respect to climate and/or fire, it is classified as such. It occurs on the poorer droughty shale breaks and terraces above watercourses such as those near the Yellowstone, Tongue, and Powder Rivers and along Armells and Rosebud Creeks.



EXISTING VEGETATION TYPES

🟩 1) Douglas Fir
🟩 2) Eastern Ponderosa Pine
🟩 3) Ponderosa Pine Savanna
🟩 4) Cottonwood – Willow
🟩 5) Boxelder – Green Ash – Rose – Chokecherry
🟫 6) Big Sagebrush – Western Wheatgrass
🟫 7) Big Sagebrush – Western Wheatgrass – Grama
🟫 8) Big Sagebrush – Western Wheatgrass – Needle & Thread – Grama
🟫 9) Big Sagebrush – Grass
🟫 10) Silver Sagebrush – Greasewood
🟨 11) Bluebunch – Wheatgrass – Fescue
🟨 12) Western Wheatgrass – Needle & Thread – Green Needlegrass
🟨 13) Needle & Thread – Western Wheatgrass – Grama
🟨 14) Western Wheatgrass – Needle & Thread – Grama
🟨 15) Grama – Western Wheatgrass – Needle & Thread
⬜ 16) Badlands
▨ Agricultural
● Near Pristine Vegetation

SOURCE: Melvin S. Morris, MSU Ag. Exp. Station, USFS, SCS

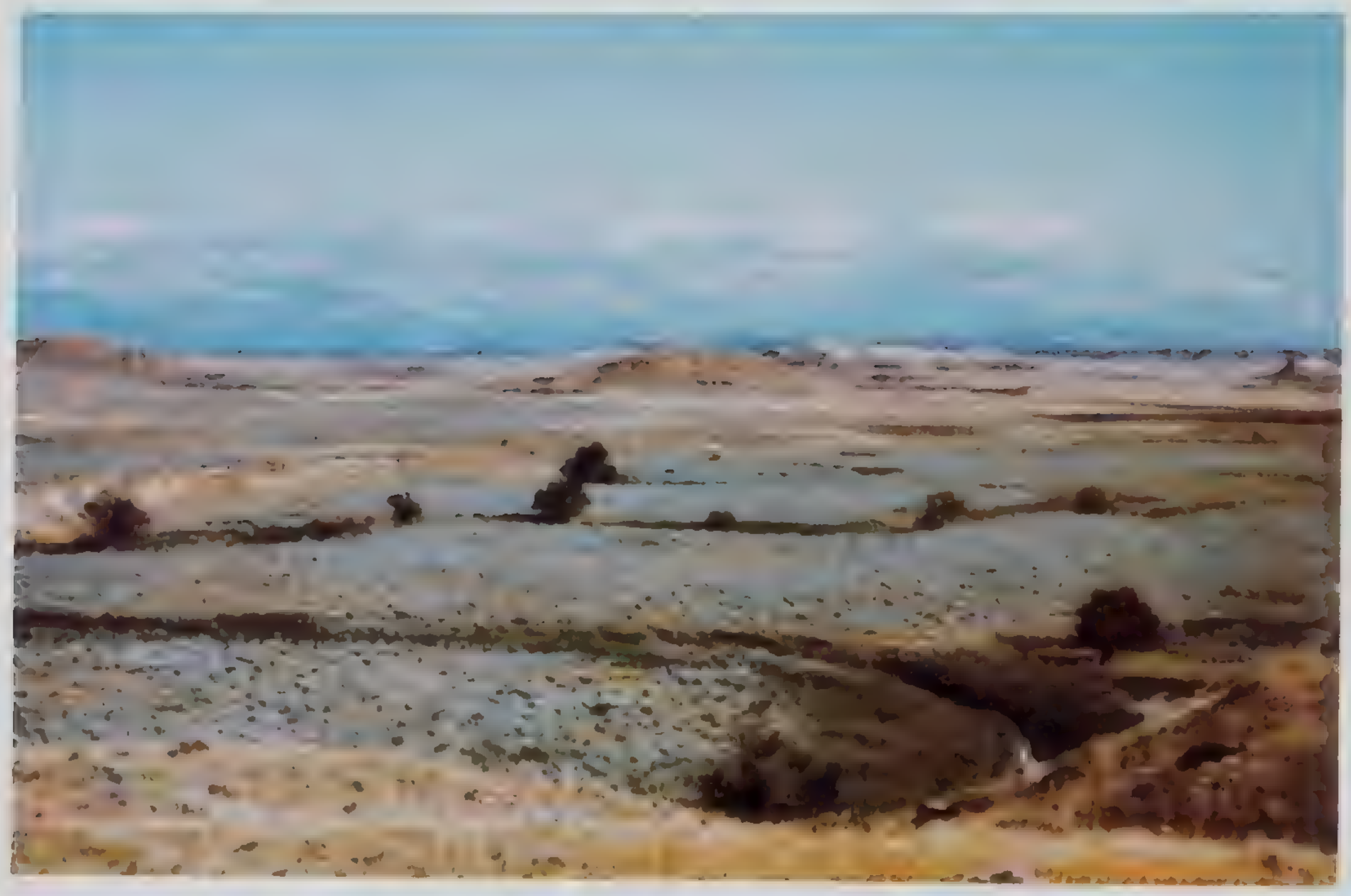
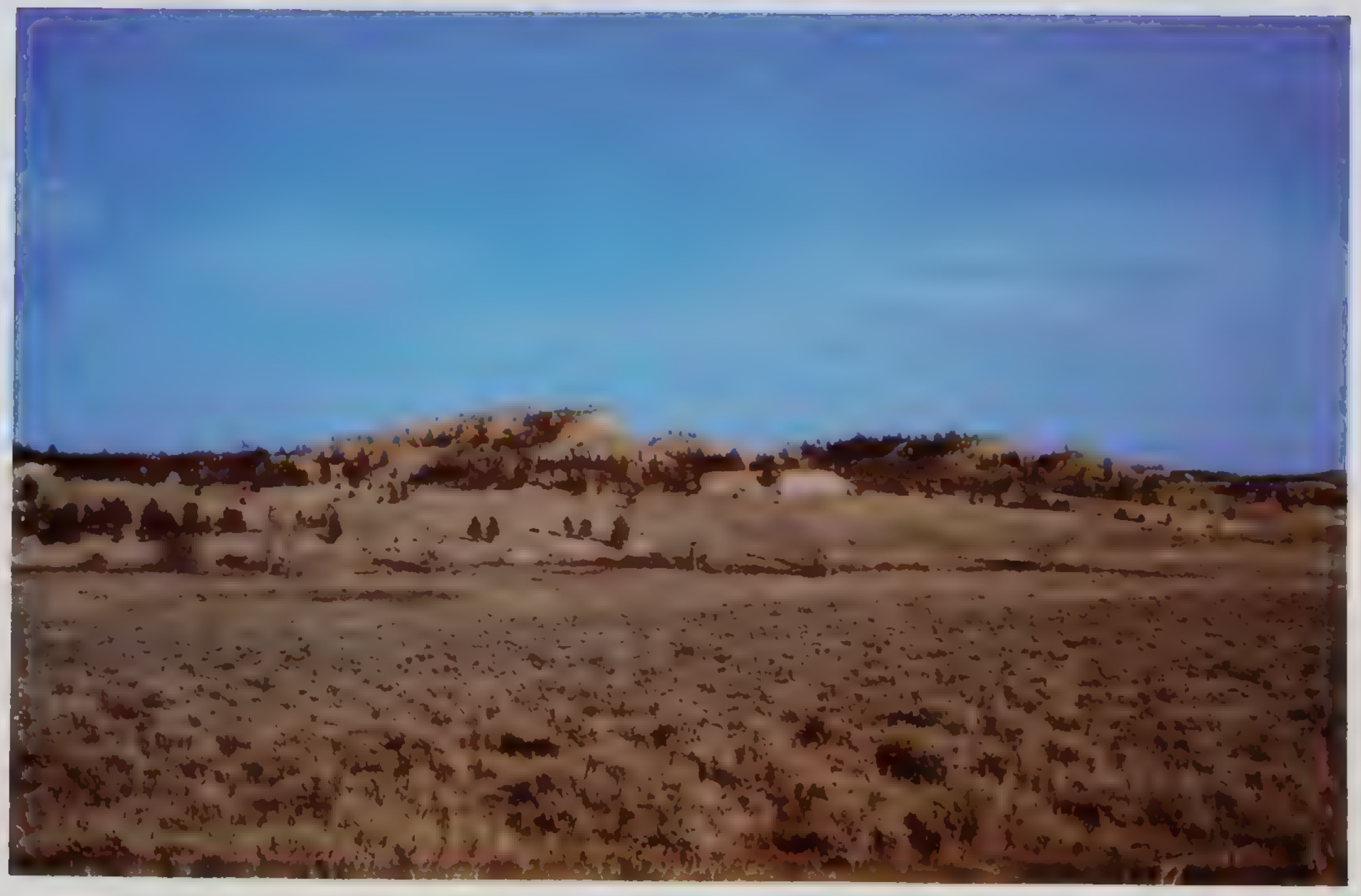


Figure 10-24

View of the rangeland in the Sarpy Creek area taken in August, 1973

Figure 10-25

Vegetation types of sagebrush (foreground), riparian (middleground), and pine (background) on the West Fork of Armells Creek.



The ponderosa pine grows on stony or gravelly knolls; highest density occurs on the north slopes. Because of the growing conditions, growth of these trees is stunted and they rarely reach commercial size (Dyksterhuis 1957).

The cottonwood-willow type occurs along the Yellowstone, Bighorn, Tongue, and Powder Rivers.

The boxelder-green ash-rose-chokecherry type occurs mainly along Rosebud and other smaller creeks within the study area. These two riparial vegetation types are important for stream bank stabilization and providing habitat for extensive numbers and species of wildlife.

The big sagebrush-western wheatgrass type occurs on the Tullock member of the Fort Union geologic formation. The boundaries of this type should be considered approximate because of incomplete geologic mapping and the lack of a sharp ecotone between sagebrush and grassland. Within the Tullock member there are some relatively pure grassland areas. The Tullock is not amenable to sharply delineated vegetation boundaries because it contains good sandy areas and many shale areas. Grass and shrub combinations are generally tied to sandy and loamy soils, while sagebrush dominated vegetation is more closely associated with shaley (clay) soils. Within the sagebrush areas there may be a combination of big and silver sagebrush. When using soils classification at a series level for mapping vegetation boundaries it should be noted that soil-plant relationships aren't always consistent, especially if over-grazing and fire have occurred. In general, sagebrush occurs on vertisols, shale, and shale-derived materials. Yucca, needle-and-thread, and threadleaf sedge may be associates of considerable extent on sandy, rocky, or gravelly soils.

The big sagebrush-western wheatgrass-grama type was mapped using the boundaries of the Lebo member of the Fort Union formation. The Lebo member can be used as a strong indicator of big sagebrush boundaries, especially if there is sufficient topographical relief. However, as with the Tullock member, soil-plant relationships are not always consistent. For example, the Lebo member has some pure grassland in it, usually on nearly level terraces (uplands). Silver sagebrush may be found on a variety of soils, sandy areas and clay soils, depending on physiographic position of the soil, grazing, and other disturbance history. Silver sagebrush occurs on upland medium-to—course-textured soil, but may occur on heavier soils in the swales and bottomland. Figure 10-25 shows a vegetation transition area from silver sagebrush to riparian to ponderosa pine on the knobs. Blue grama grows on a variety of soil textures but generally is more abundant on flat to southerly exposures. On clay loams and sandy loams with moderate grazing intensity, blue grama takes the position of second-or third-order dominance. However, under heavy grazing intensity, it can assume a first-order dominance.

Big sagebrush is the leading dominant on fairly shallow "A" horizon and shaley soils. The big sagebrush-grass type occurs on a variety of sites. Because of this no single grass species is dominant. Some common dominant grasses are bluebunch wheatgrass, rough fescue, and green needlegrass.

The silver sage-greasewood type occurs near the Hardin area and along the Tongue and Powder Rivers and other smaller drainages in the study area. Either species may occur in pure stands or both may be combined in a co-dominant situation. In areas where the soils are more alkaline, greasewood dominates or occurs in pure stands. In the moister areas, silver sage dominates or occurs in pure stands. Associated species are listed in Appendix D3.

Western wheatgrass, also an associate of each of the sagebrush types, is an accumulator of selenium. With increases of selenium in the soil due to power plant stack emissions, a selenium accumulator as widespread as western wheatgrass could cause problems for the livestock industry.

The foothills grassland-bluebunch wheatgrass-fescue type occurs only in the southwest corner of the study area in elevation just below the Douglas fir type. Bluebunch wheatgrass is dominant on the lower south and southwest slopes. It generally prevails on gravelly and sandy soils and also appears on soils having cracks at the surface extending down into the "C" horizon of the soil profile, where moisture can accumulate (Morris 1973). Rough and Idaho fescue occur on north and east slopes and share dominance with bluebunch wheatgrass. However, with increase in elevation, either rough or Idaho fescue dominates and bluebunch wheatgrass becomes uncommon. The fescues grow on moderately deep, course-to medium-textured soils.

The mixed prairie grasslands in the study area vary in species dominance due to soil texture and structure and give rise to four grassland types. The western wheatgrass-needle and thread-green needlegrass type; needle and thread-western wheatgrass-grama type; western wheatgrass-needle and thread-grama type; and big sagebrush-western wheatgrass-needle and thread-grama type. Western wheatgrass is dominant in swales and where there is clay or clay loam in the "B" horizon. Green needlegrass is commonly associated with western wheatgrass and is more abundant on cracking clays (vertisol soils), especially silty clay loam.

Green needlegrass is highly palatable and sensitive to grazing pressure; under heavy grazing, it is the first species to drop out. Needle-and-thread is dominant if the "A" and "B" horizons are silty to sandy loams. Blue grama occurs on a variety of soils but is more prevalent on drier sites and increases in dominance with greater grazing pressure, resulting in another type, grama-western wheatgrass-needle and thread. Big sagebrush is the leading dominant species in areas having fairly shallow "A" horizons, warm sites (sloping to the south) and heavier grazing activity. Big sagebrush also prevails on shaley soils of the uplands.

The badlands vegetation type is unique in that distinct boundaries can be indicated, and vegetation cover is generally sparse (see Figure 10-26). This type occurs in the Miles City area and in the area of the Ashland Ranger District of the Custer National Forest. This type is distinguished by communities rather than any single dominant species. Each community, however, is represented by one or more dominant species as described by Brown (1971a). The greasewood community occurs on interbedded clay and silt shale soils with high sodium content. Stands are normally found on middle and lower slopes of southwest and southeast exposures. In shadscale-big

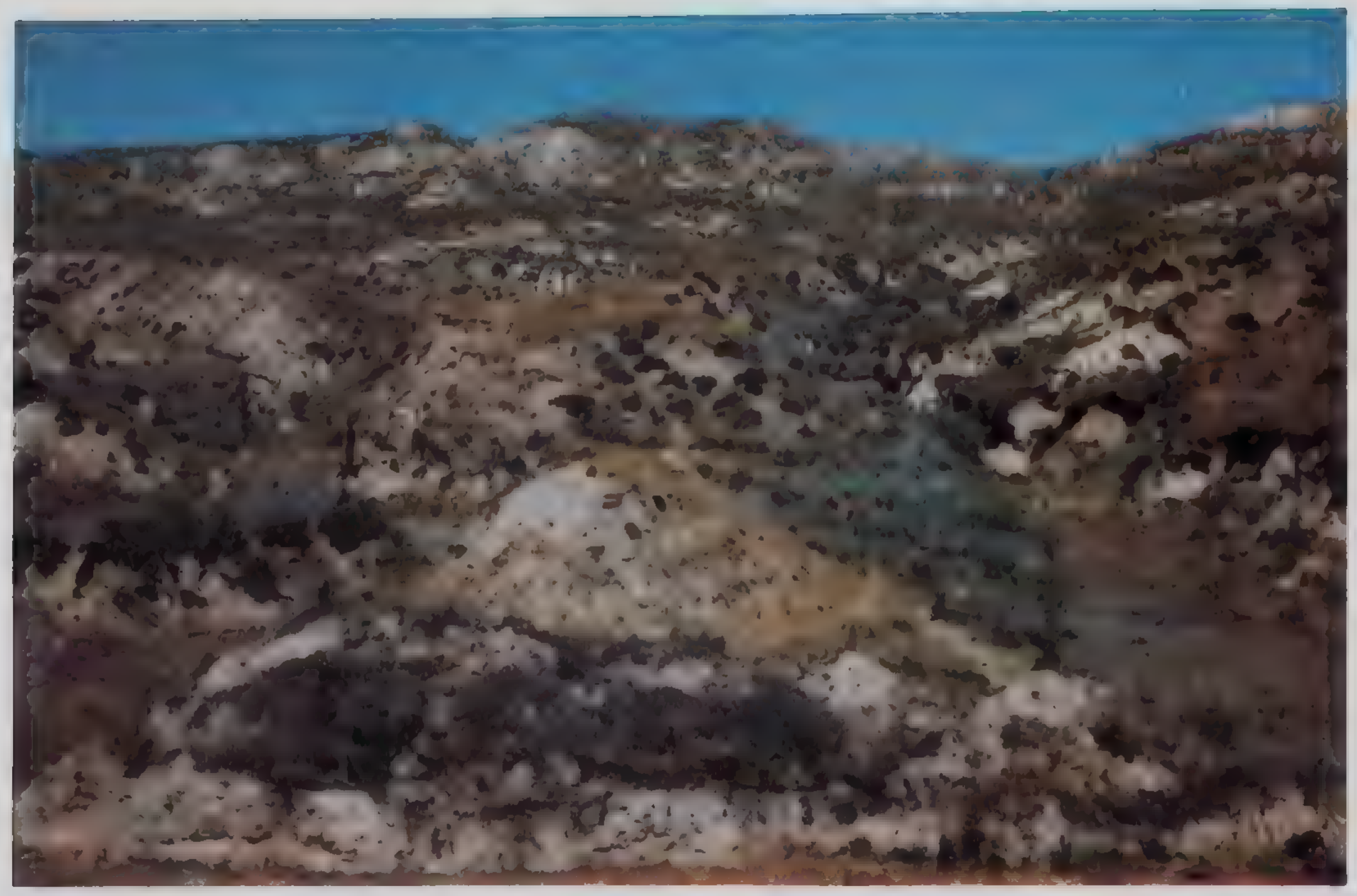
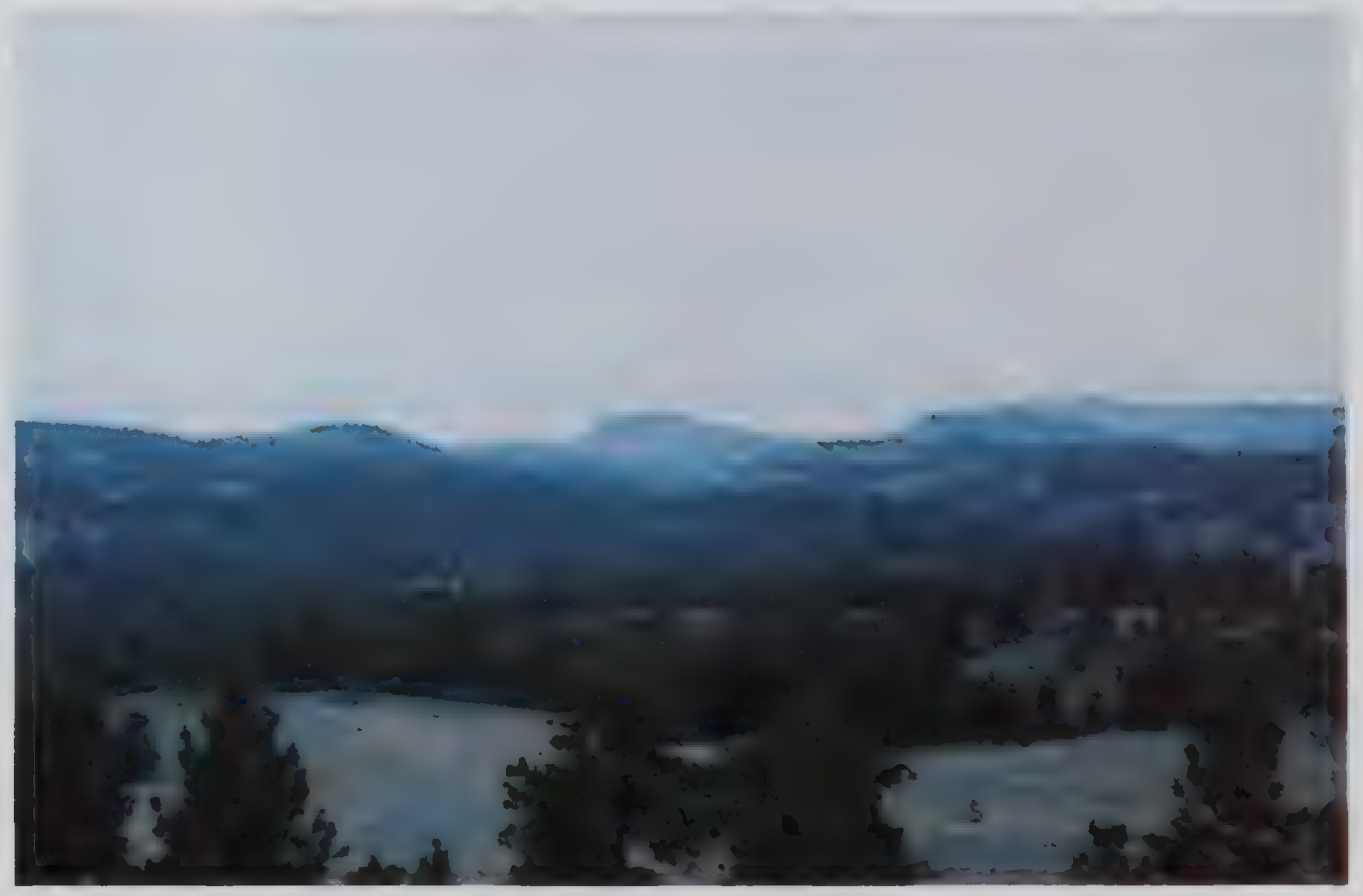


Figure 10-26

Badlands vegetation type south of Miles City.

Figure 10-27

Ponderosa pine type of the Custer National Forest taken from Poker Jim Lookout.



sagebrush communities vegetation cover is vary sparse, with only a few grasses and forbs. Soils of this community are generally heavy textured with clay in the upper horizon and clay loams in the lower horizons. This community exists on steeper slopes on exposed clay and silt shale beds. The big sagebrush-shadscale-bluebunch wheatgrass community is characterized by soils with clay loam in the upper horizon and silt loam in the lower. This community is found on talus material of sandstone fragments and clay and silt shale on southwest and southeast exposures. The big sagebrush-bluebunch wheatgrass communities are characterized by more or less uniform clay loam soils on moderate slopes of talus materials. Sodium content is much lower than that of the soils of the above communities. Stands occur on lower slope positions of southwest and southeast exposures. The skunkbush sumac-bluebunch wheatgrass community soils are composed of porcellainite material with a textural range from sands to loams. Stands are generally on or just below ridge tops of west to southeast exposure. The Rocky Mountain juniper-bluebunch wheatgrass community is restricted to clay and clay loam soils with low calcium and sodium content. The southwest and northwest slopes of the deeper channels and side drainages are the principle locations of this community. Knolls at the base of badlands slopes characterize the main locations of the ponderosa pine-Rocky Mountain juniper type. Soil textures of this community are heavy clay loams and silt clays. Pine is uniformly scattered across the knoll surface while the sloping sides are covered mainly by juniper. This type is considerably more fragile than the others in the study area. Vegetation growing there is specialized to the extent that it consists of the only native species that can grow there. The shallow, ususally undeveloped soils and steep slopes, are the primary limiting factors involved in species distribution of the area.

10.1.6.2 Relict Areas

Many areas in Montana have original near-pristine vegetation (SCS 1973). Climax plant communities are recognized as being ecological standards in monitoring ecosystems. Relict areas are used for study and comparison of presently existing vegetation against the potential of the site. Should these areas be disturbed by man, unique situations of relatively stable vegetation in a state of dynamic equilibrium will be lost, and study of them will therefore become impossible. The relict areas within the study area shown on the Vegetation Types Map, are Melstone Cemetery, Custer Battlefield, Reno-Benteen Battlefield, Wagon Box Cemetery, Creek-Decock Ranch, Theony Cemetery and the north slope of Pompey's Pillar.

A. Method of Data Collection

Vegetation inventory for the study area was begun by compiling existing data, such as maps and previous vegetation studies within the area. The primary reference for all vegetation inventory is the map, "Natural Vegetation of Montana " (Morris 1964), which covers the entire state. All other mapping was done on $\frac{1}{2}$" = one mile base maps with 160 acres as the smallest mapping unit for vegetation types. Field checks and periodic point observations were made to correct and supplement the maps and existing data. Information noted at each observation point included:

1) Associated species lists for each type

2) Topography (landform elevation aspect)

3) Soils (texture)

4) Major resource uses (if evident)

5) Range Condition (ocular estimate)

6) Range Production (ocular estimate)

7) Poisonous and noxious plants

10.1.6.3. Forest Resource

Forests in the study area are generally not as plentiful and do not achieve the tree size of forests in central and western Montana. Consequently, their value as a timber resource is overshadowed by their importance for watershed, recreation, and wildlife values. The scarcity of large continous forests in eastern Montana and the difficulty in reestablishing them results in trees being valued for their scenic beauty (uniqueness) by most local residents.

Not discounting their value for other purposed besides timber resource, the parameters that best enable impact evaluation of the environment and on the environment are tree size, forest stocking, and timber production.

Forests in the study area are primarily uneven-aged stands compared to the predominantly even-aged stands of central and western Montana. The major tree species in the study is ponderosa pine, sometimes occurring with Rocky Mountain juniper. Douglas fir is found toward the southern part of the study area, especially in the Big Horn Mountains, occurring with lodgepole pine and quaking aspen. Broadleaf trees occurring along rivers and streams include cottonwood, box elder, and green ash (see Vegetation Types Map).

Because of limited rainfall (10-14" annually) and the more frequent occurrence of drought conditions, tree heights in the northern and central portion of the study area average 30-50' and seldom exceed 60' (Pyke 1974). Tree height increase from the northern to the southern portion, which receives more annual precipitation 15-20"). Average tree heights of the Ashland and Fort Howze Ranger Districts of the Custer National Forest are 50-55' the tallest trees are 70-80' (Turner 74). Tree heights on the Crow and Northern Cheyenne Indian Reservations average 55-60'. Occasionally, in old growth stands, trees may reach 80-90' (Ferry 1974).

A. Tree Size

Tree diameters also increase from the northern to the southern part of the study area. Average diameters for the small portion of the Bull Mountains included in the study area are 10-11" diameter at breast height (d.b.h.) (Pyke 1974, Roberts 1974). The Pine Ridge area south of the Yellowstone River has diameters similar to these in the Bull Mountains. The divide area west of Colstrip has trees averaging 13-14" d.b.h. (Pyke 1974). Ponderosa pine trees in the Custer National Forest average 15" b.b.h., but some trees as large as 30" d.b.h. have been found (Turner 1974). Old growth stands in the Crow and Northern Cheyenne Indian Reservations average 24-

26" d.b.h. and trees as large as 36-38" d.b.h. have been measured (Ferry 1974). Young growth ponderosa pine usually averages about 12" d.b.h.

Cottonwood trees along the watercourses average 24" d.b.h. but some may exceed 48" d.b.h. Box elder and green ash diameters range from 6-9" d.b.h. (Pyke 1974). Tree diameters for commerical stands are shown by size classes on the Tree Size Map.

B. Forest Stocking

Most of the counties in the study area are poorly stocked except on the Custer National Forest (see Figure 10-27) and the Indian reservations. Overstocking on the Crow Reservation has resulted in a problem that will be discussed later. Excluding federal ownership, the counties with the highest stocking class are Rosebud, Treasure, and Big Horn counties (Pyke 1974). Forest stocking for the various counties can be seen on the Forest Stocking Map. In general, forest stocking is greater on north, east, and northeast slopes due to cooler, moister growing conditions.

C. Forest Production

Tree size and forest stocking can be used to make rough approximations of board foot volumes per acre (bd. ft/acre). Besides the two parameters given above, true volume per acre is determined by total tree height, form, age, species, locality, and site index. Table 10-36 shows approximate volumes per acre by tree size and stocking class for the Custer National Forest.

TABLE 10-36

Custer National Forest
(board feet/acre)

	Well Stocked	Medium Stocked	Poorly Stocked
Sawtimber	8,500	4,500	1,000
Pole Timber	7,000	3,000	500

According to Ferry (1974), average volumes on the Crow and Northern Cheyenne Reservations are 4,500-5,000 bd. ft/acre. Some moist sites in the bottoms may yield as much as 10-12,000 bd. ft/acre.

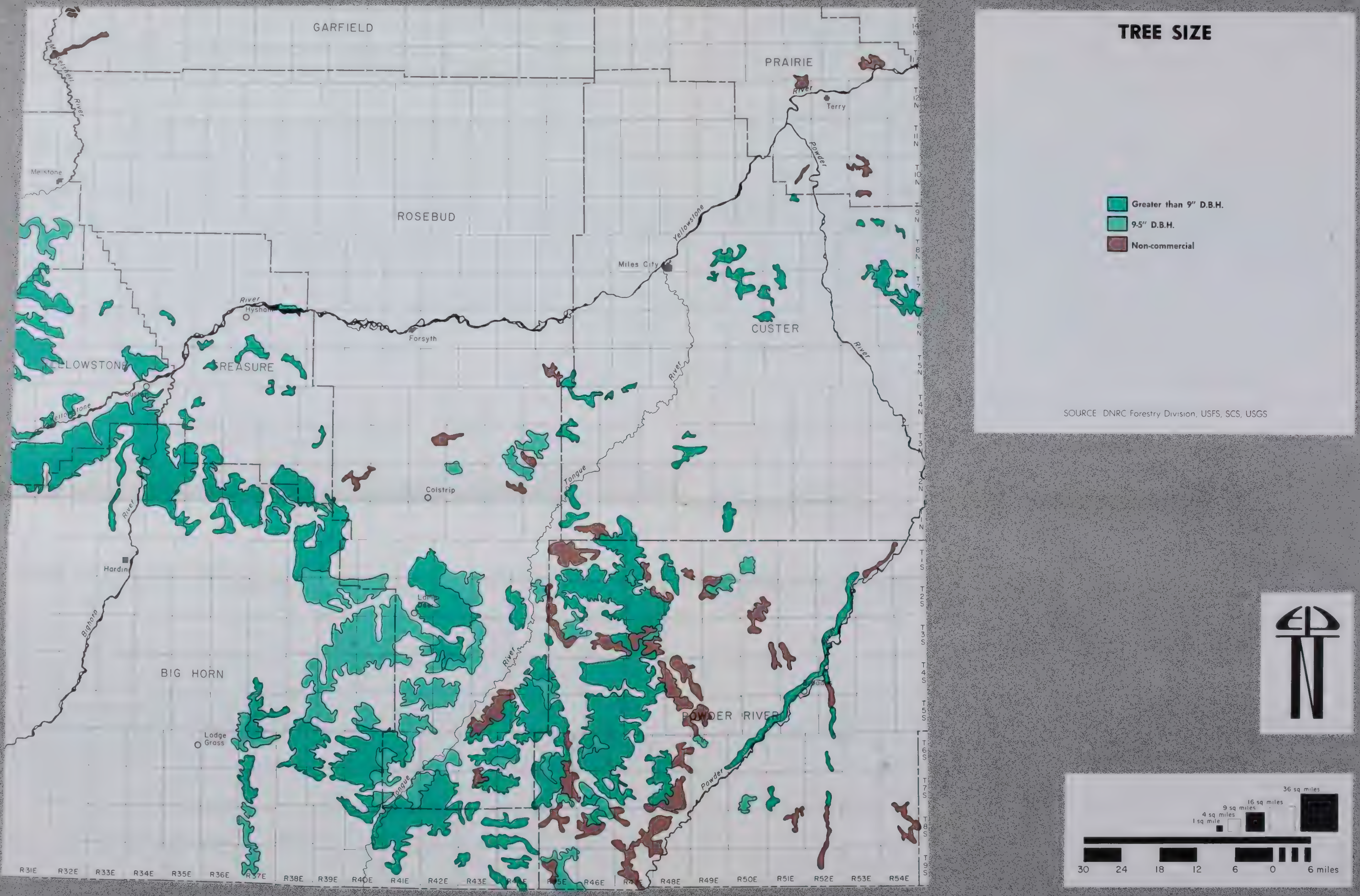
Timber volumes on the Custer National Forest average about 4,400-5,000 bd. ft/acre. Yields as high as 8-10,000 bd. ft/acre occur on steep, short north slopes, especially on Campspass and Pigeye soil series that are very fertile. Site index on these soils is 70 (with 100-year base) but the average for the forest is 45 or less (Turner 1974).

The Bull Mountains and the Pine Ridge area have mean volumes of 1,500-4,000 bd. ft/acre (Pyke 1974).

The Divide area west of Colstrip averages volumes of from 5,500 bd. ft/acre on the crest and slightly east and west of the crest to 2-3,000 bd. ft/acre on the footslopes east and west of the divide (Pyke 1974).

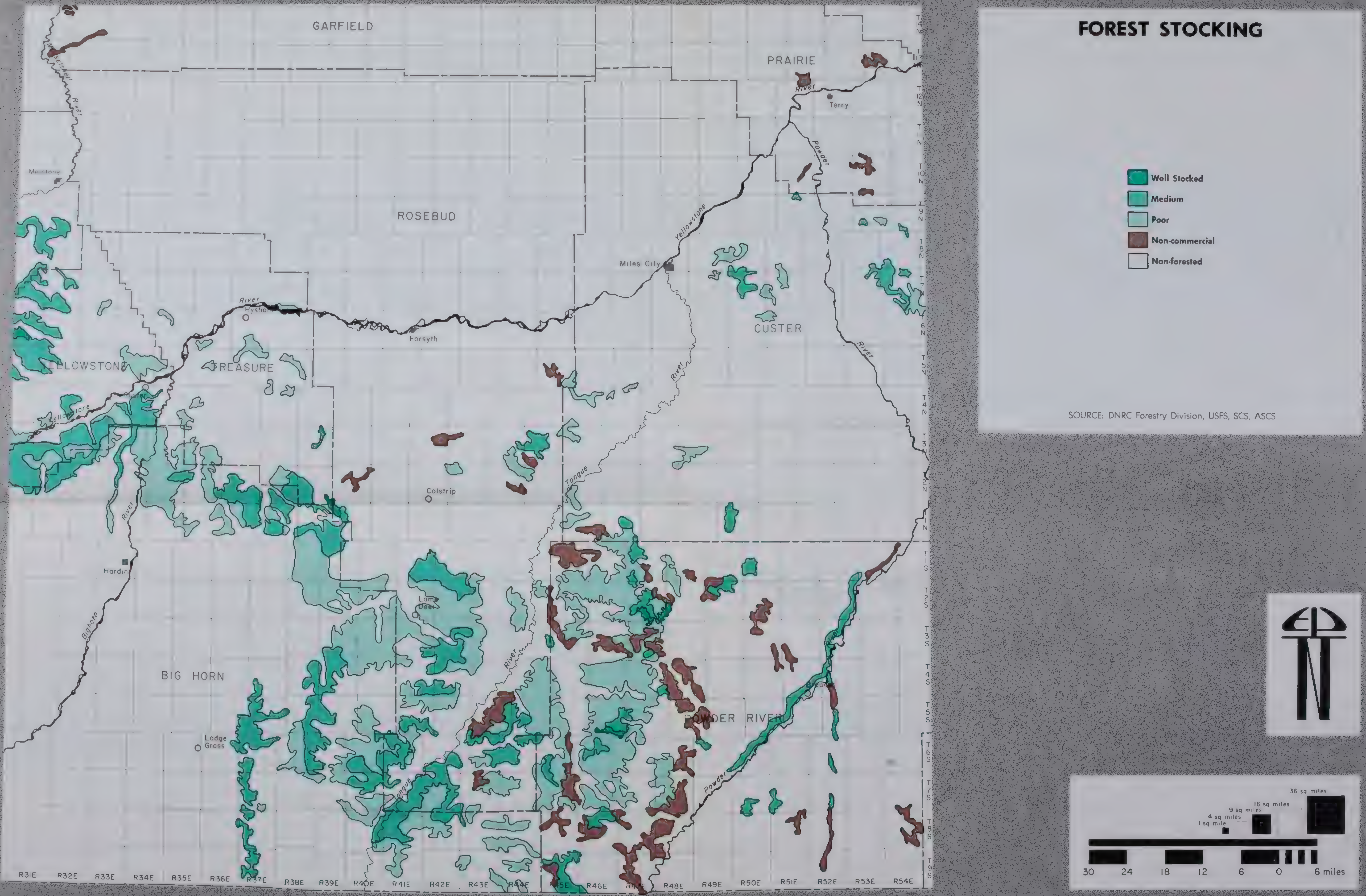
Volumes per acre for the various counties

TREE SIZE



SOURCE DNRC Forestry Division, USFS, SCS, USGS

FOREST STOCKING



SOURCE: DNRC Forestry Division, USFS, SCS, ASCS

are indicated on Table 10-37. Yields per acre will be different than those shown in Table 10-36 because the values in Table 10-37 were calculated by dividing the total commercial board foot volume (soft woods and hardwoods) for each county into the total commercial acreage for each county, including federal, state, and private ownership. Volumes in Table 10-36 represent only the national forest land portions of Rosebud and Powder River Counties. Values for this table were derived by applying the average site index (45) of both size classes (sawtimber and pole timber) for each of three stocking categories (well, medium, and poorly stocked) to U.S. Forest Service local volume tables. Table 10-36 is therefore more site-specific than Table 10-37, although still general.

D. Forest Industries

Forest products are primarily provided from the Custer National Forest, the Crow and Northern Cheyenne Indian Reservations, the divide area west of Colstrip, the Pine Ridge area, and the Bull Mountains. The forest resource for the remainder of the study area consists of small, discontinuous stands on the cooler northern and eastern slopes. Small tree diameter and uneconomical hauling distances limit use of these stands except locally for posts and poles and small marginal sawmills.

Ponderosa pine trees harvested from the Wolf Mountains on the Crow Reservation are made primarily into studs. Douglas fir and lodgepole pine from the Big Horn Mountains are chiefly used for posts and poles; a small amount (1%) is made into boards (Ferry 1974).

Trees harvested from the Custer National Forest are chiefly used for studs and some construction ties.

Trees harvested on state and private lands on the other significant forest areas are made into studs (70%) and rough lumber (30%) (Pyke 1974).

The study area has approximately 12 sawmills that serve certain commercial portions of the study area. Most of the small mills have maximum hauling distances of about 50 miles, while the larger mills, including some in Wyoming, have maximum hauling distances of 75-110 miles (Pyke 1974, Ferry 1974).

E. Forest Conditions

Forest condition is a measure of the overall health of the forest considering such factors as insect and disease epidemics and possible air pollution damage.

Overstocked stands with reduced tree vigor have resulted in epidemic outbreaks of mountain pine beetle on the Crow Indian Reservation. Some Ips beetles have been discovered in slash remaining from logging operations, but no epidemic beetle populations have been observed in nearby standing live trees (Ferry 1974).

The nearby Custer National Forest reports that from 400 to 600 acres of ponderosa pine have been badly damaged by the leaf-defoliating pine looper. Ips beetles have also been observed on the edges of this infested area. The only disease problem in the study area is red heart rot in old

TABLE 10-37

Sawtimber Volumes and Commercial Forest Acreages for Counties in the Study Area

Counties	Year of Inventory of volumes	(Hard & Softwood) Timber Volumes Thousands bd. ft.	Acreages of Commercial Forest land	Avg. bd. ft. Acre (Thousands)
Big Horn	1949	113,345	179,185	632
Custer	1949	26,693	25,092	1,063
Garfield	1948	21,463	69,611	308
Musselshell	1949	273,844	247,381	1,107
Petroleum	1948	5,904	22,668	260
Powder River	1949	209,038	169,791	1,062
Prairie	1948	11,939	2,170	5,502
Rosebud	1947	119,066	151,941	784
Treasure	1949	19,772	24,418	810
Yellowstone	1949	62,215	58,412	1,065

growth ponderosa pine (Turner 1974).

The only insect problem on state and private forests is the mountain pine beetle in the Little Wolf Mountains (Kohler 1974).

For an account of existing air pollution damage in the study area, see Section 10.1.6.6.

F. Method of Data Collection

The forest stocking and tree size maps on state and private lands came from the 1960-63 forest inventory of the counties made by the Forestry Division of DNRC (the old State Foresters Office). If the county was not included in the statewide inventory, stocking classes were derived from aerial photographs and diameters came from interviews with land managers and verification with field spot checks. Stocking and size on federal lands came from the U.S. Forest Service, BIA and BLM.

The Forest Service maps came from 1957 and 1968 inventories. The BIA maps were from 1972-73 inventories and BLM maps were from 1964-74 inventories. The available maps were traced on over-lay material using a base map scale of $\frac{1}{2}$" = 1 mile. The smallest mapping unit for both stocking and size was 160 acres.

The forest maps on state and private land do not show any forest cuttings which occurred after the 1960-63 inventory.

Forest production data came from the most recent data available; for state and private lands the oldest source used was 1949. Most of the recent data for state and private lands came from the Soil Conservation Service.

10.1.6.4. Range Resource

Rangeland within the study area is approximately 85% of the total land area. This resource is important to the state in many ways. Montana's largest industry, livestock production, depends on forage production by the range to meet the ever-increasing demand for livestock products. A tremendous variety of wildlife species are supported by rangeland throughout the study area. Many recreational activities are closely associated with the range resource; it provides hunting and fishing locations, scenic beauty, and space to find solitude and quiet. In a more practical sense, the range also is a watershed and is thus closely connected to effective water conservation and management.

The value of the range resource is indicated by range condition, production, and trend. Management decisions related to this resource can be made on the basis of evaluations of these parameters.

Each vegetation type offers its own livestock, wildlife, recreation, and watershed uses. In order for the rangeland to supply these needs, range vegetation must be in good condition and forage production must be capable of supporting livestock and wildlife in conjunction with other uses.

The parameters used to evaluate the range resource are complex, highly interrelated, and dependent on climate, soils, grazing history, and present management practices.

Within the study area there are five major geographic range types (Payne 1973):

1) Eastern ponderosa pine woodland types

2) Foothills grassland types

3) Central grassland types

4) Badlands type

5) Southeastern grassland types

Each geographic type is distinguished by different soils, precipitation zones, and other characteristics shown in Appendix D3. Each geographic type contains one or more of the vegetation types in the study area. They are used here in place of the individual types because they represent the best data available for range condition and production estimates.

Range vegetation type (grassland, sagebrush, timbered range, broadleaf range) are shown on the Range Vegetation Type Map as a broad classification of vegetation within the study area.

A. Range Condition

Range condition is determined on the basis of percent of original plant cover (climax vegetation) and the species compostion of the vegetation types. Five range condition classes - excellent, good, fair, poor, and very poor - are used to indicate general range conditon. The Range Condition Map shows the areas within the study area where each of the five condition classes are dominant.

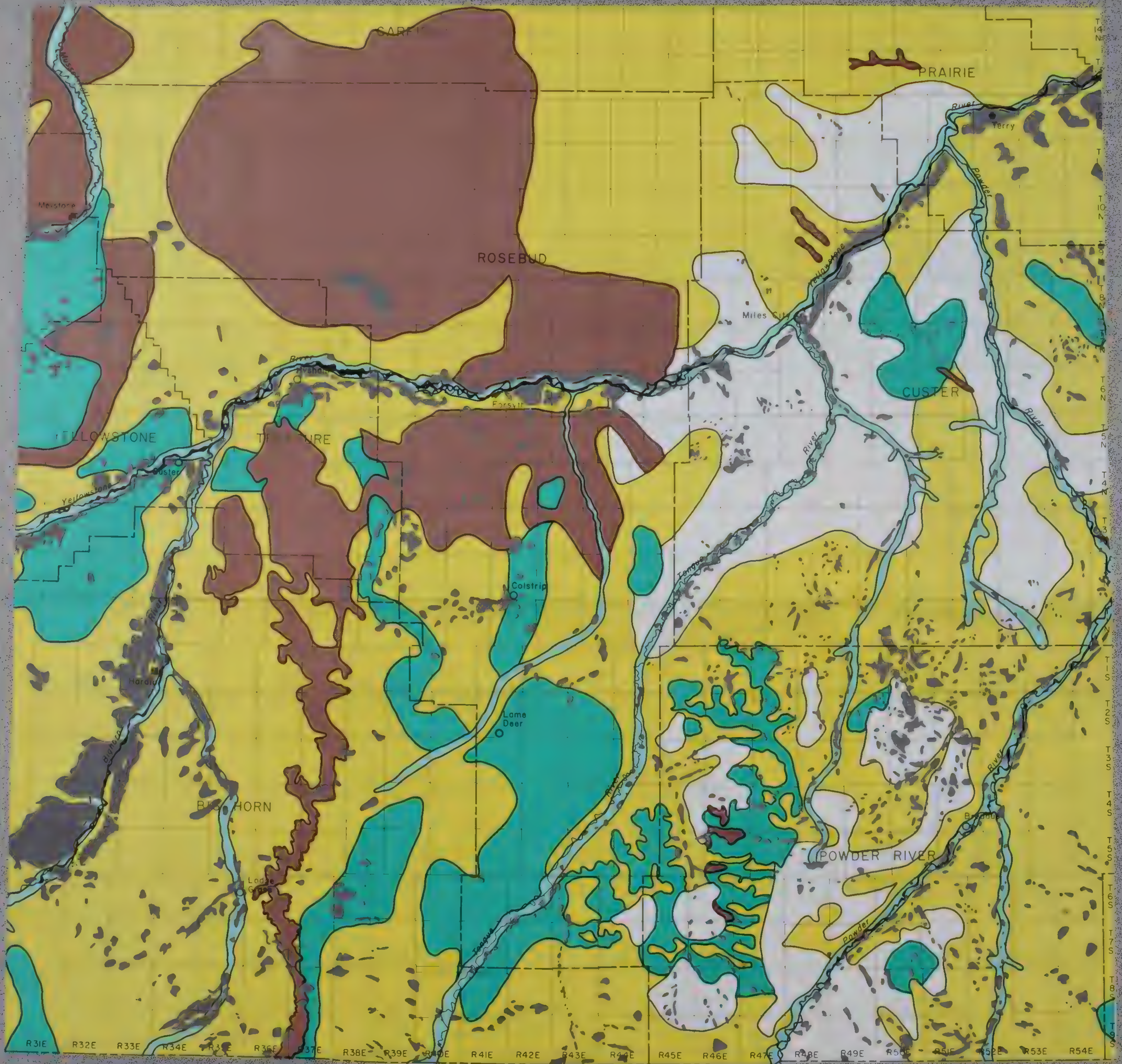
Approximately 46% of the rangeland in the study area is in good to excellent conditon; 54% is in less than good condition (Jackson 1973). The sections of the study area classified as eastern ponderosa pine savanna and woodland are in fair to good condition. The foothills grassland, predominantly the bluebunch wheatgrass-fescue type, is in excellent condition. The condition of the central grassland types and southeastern grassland types is relatively good. The badlands are in fair condition.

Range condition estimates were calculated by field observations and with the use of Soil Conservation Service (SCS) criteria for determining range condition. Animal-unit-month figures from Payne (1973) were also used for determination of condition classes.

Range condition is an important parameter to use in determining possible impacts on the range resource. Range in marginal condition could conceivably be pushed to a lower condition class as a result of disturbance from construction of the water pipeline and reduction of, or damage to, species sensitive to emissions from the power plants.

B. Range Production

Range production indicates the amount of total forage produced by a given site. Usable forage is that portion of the total forage production which can be used by both domestic livestock and wildlife without depleting the



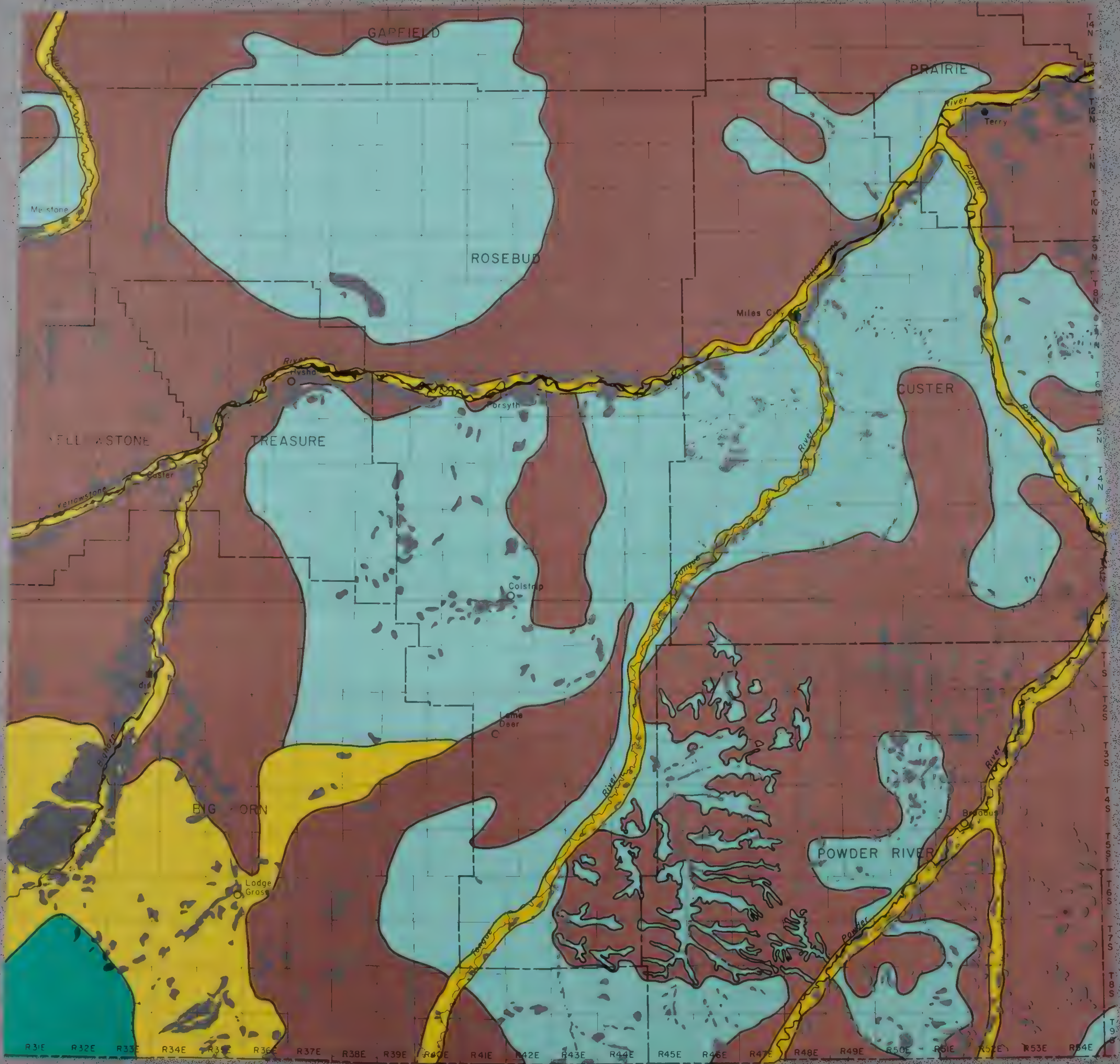
RANGE VEGETATION TYPES

- 🟨 Grassland
- 🟫 Sagebrush
- 🟩 Timbered Range
- ▨ Broadleaf
- ☐ Barren (Badlands)
- ■ Agricultural

SOURCE USFS, SCS, MSU Ag Exp Station, M S Morris

1 sq mile
4 sq miles
9 sq miles
16 sq miles
36 sq miles

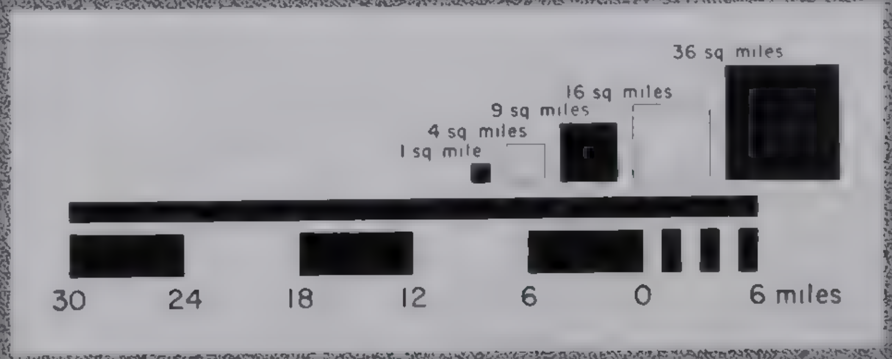
30 24 18 12 6 0 6 miles



RANGE CONDITION

- 🟩 Excellent
- ▨ Good
- 🟥 Fair
- 🟨 Poor
- ■ Agricultural

SOURCE USFS, SCS MSU Ag Exp Station



resource through overuse. Range production is strongly tied to condition. For example, vegetation species with high forage values, generally climax or near-climax species, are more abundant on ranges of the higher condition classes; therefore production is higher.

Production is measured in acres per animal-unit-months (A/AUM). An animal unit is considered to be 1,000 lb. live weight, roughly equivalent to the weight of a cow and a calf. Average range production figures show only a small amount of variation within the study area. Production estimates for the five geographic range types are as follows:

1) Eastern ponderosa pine types
3.5-4 A/AUM

2) Foothills grassland types
3 A/AUM

3) Central grassland types
3.5-7 A/AUM

4) Badlands type
5.5 A/AUM

5) Southeastern grassland types
3-4 A/AUM

Range production estimates were taken from Payne (1973) and incorporated with condition class precipitation zones and vegetation types. Table 10-38 gives range production figures for the study area in more detail.

TABLE 10-38

FORAGE PRODUCTION ESTIMATES (LBS/AC)

Custer National Forest

	Excellent and Good Condition	Fair Condition	Poor and Very Poor Condition
Grassland	1,400	1,000	600
Sagebrush	1,000	600	300
Timbered Range	1,000	600	200

C. Range Trend

Range trend is an indication of the direction of change in range condition relative to the past. For example, if the range was in fair condition ten years ago but is now in good condition, the trend is upward.

Range trend is influenced strongly by climate, soils, and management practices. With above-normal annual precipitation over the past two decades and application of more intensive management, there has been some improvement in condition, especially on specific ranches and allotments creating an overall upward trend. However, on some heavily used pastures within the study area, trend is downward.

10.1.6.5. Poisonous and Noxious Plants

Within the study area, several plant species have been classified as noxious or poisonous plants.

Range plants considered noxious or undesirable are those species poisonous to grazing animals, unpalatable increasers, or species which act to suppress the growth of more desirable species through competition (Florez et al. 1972).

The most noxious plant species within the study area are broom snakeweed, field bindweed, cheatgrass, Canadian thistle, and leafy spurge. Russian knapweed and whitetop are two noxious species on the increase in the area, but as of yet, are not major problems. Many noxious plants are introduced exotics and are highly competitive with the desirable native species.

Poisonous plants are not generally a problem in the study area. Most species of poisonous plants are dangerous only at certain times of the year, and then usually only some parts (e.g. leaves, roots, fruit) are poisonous. Poisonous species common to the area are cocklebur, low larkspur, lupine, black grass, and locoweed. Some arrowgrass is found in lesser quantities. Cocklebur and arrowgrass are the most poisonous species and have been responsible for some cattle losses, but they are not a major problem. (BLM 1969 and 1971). Two potentially poisonous plants are chokecherry and greasewood. Chokecherry, a browse species commonly used by wildlife, is dangerous after a frost or a sudden, severe drought (BLM 1967). Greasewood, also used as a browse species by wildlife and livestock, is poisonous in the early spring when the alkaline content is highest in the leaves.

The class of livestock (horses, cattle, sheep, or goats) grazing on an infested range is important, since not all classes are affected by the same poisonous plants. Livestock poisoning is likely to occur when animals are extremely hungry, such as after a prolonged storm. During drought periods, a lack of normally grazed, palatable species forces use of unpalatable and poisonous species that would otherwise be avoided. Another cause of unusual hunger is placing livestock on the range in early spring. Because poisonous plants are often early-growing, they may be grazed before good forage becomes available.

A more complete poisonous-noxious plant species list is shown in Appendix D2.

10.1.6.6. Vegetation Chemical Analysis

In order to assess the impacts on vegetation which would occur due to the emissions of power plant units at Colstrip, it is necessary to establish baseline levels of phytotoxins in vegetation of the Colstrip area. Phytotoxins studied include sulfur dioxide, nitrogen oxides, particulates, and fluoride.

A. Sampling Site Selection

Vegetation samples were collected from 35 sites in the area surrounding Colstrip in two "sets", one in the fall of 1973 and the other in the spring of 1974. The major considerations for the selection of sampling sites included the following:

1) The site should have the most prominent exposure in the immediate vicinity (within a radius of two to six miles) of the sampling area.

2) It should have diverse species of vegetation with special emphasis on the presence of ponderosa pine and bluebunch wheatgrass.

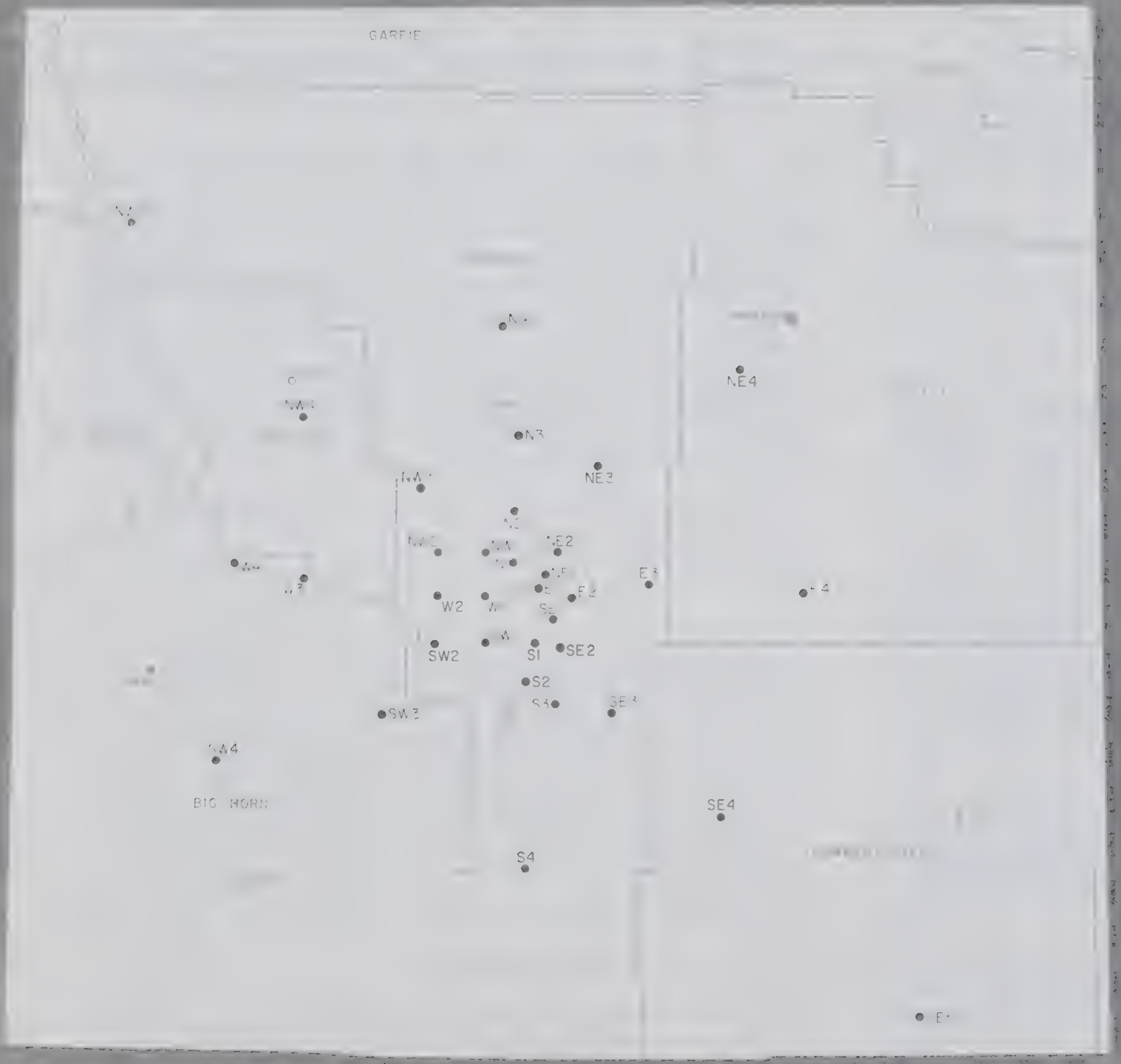
3) The sampling site should be maintained for long-term investigation. Therefore, special consideration was given to state and federally-owned lands even if the sampling site would have to be moved two to thirteen miles from one of the eight radii, which were established by utilizing wind data from Dr. Super's meteorological studies (1973) in the Colstrip area for MPC (see Section 11.1.1.).

4) Of the 35 sites established along these eight radii emanating from Colstrip, only seven (20%) were established on lands of private ownership, three (8%) on Indian reservation lands, 17 (49%) on state of Montana lands, and eight (23%) on federal lands.

Figure 10-28 is a schematic drawing of a map of the Fort Union Basin area of Colstrip. Double circles on the map depict the approximate location of each of the 35 sampling sites chosen and utilized for baseline study.

Six major species of plants were chosen for chemical analysis: 1) skunkbrush, 2) big sagebrush, 3) Rocky Mountain juniper, 4) bluebunch wheatgrass, 5) little bluestem, and 6) ponderosa pine. These species were picked not only because they are prevalent throughout the area, but also because they are either faster accumulators of pollutants or are slow accumulators but manifest air pollution damage very rapidly.

A detailed collection of plant species was made at 12 of the 35 sampling sites during the summer of 1974. A table listing every plant species found at these 12 sites is presented in Appendix D1. Two other sites close to Colstrip which the EPA will be stressing with SO_2 fumigation tests in the spring of 1976 were also surveyed. These sites are also included in Appendix D1. A detailed discussion of data collection and laboratory analysis procedures for each phytotoxin follows.



VEGETATION SAMPLING SITES

FIGURE 10-28

A. Laboratory Methods of Vegetation Handling and Chemical Analysis

1. Preparation of Vegetation for Chemical Analysis

As soon as practical after receipt at the laboratory, foliage of each vegetation sample was removed according to year of foliage in the case of pines, or as a composite in the case of other plants, and placed in a paper sack containing the sample number and foliage year, if appropriate. The samples were either transferred to a forced draft oven or stored in boxes until room was available in one of the two ovens. After drying under forced draft for at least three days at 90° F., the samples were ground in a Wiley mill to pass 40 mesh, placed in a 30 dram vial with an identifying label, and stored in a plastic sack by site until analyzed.

Each step in the analysis procedure was recorded on a permanent sample log sheet. This sheet contained the sample number, date collected, species, collector's name, place collected, and space for other comments or observations. Additionally, the sample type, year of foliage or composite, and dates dried, ground, and analyzed were recorded on the log sheet. Finally, the results of all analyses were entered.

The steps in preparation and analysis may be conveniently viewed from the following flow chart (Figure 10-29).

2. Fluoride Analysis of Vegetation

The method of fluoride (F^-) analysis of vegetation employed in this study was developed in 1970 at the University of Montana Environmental Studies Laboratory. This method incorporates the Orion fluoride specific ion electrode as the fluoride sensor. It is precise and rapid, and the results of comparative studies using other techniques show very close agreement.

0.50 grams (g.) of dried, ground plant material was placed in a 35 milliliter (ml.) nickel crucible with 0.05 g. of low fluorine calcium oxide and slurried with distilled water. The slurry was first dried and then charred under infrared, transferred to a muffler furnace, and ashed overnight at 600 °C. The crucibles were covered during ashing.

When the crucibles were cool, the ash was moistened with distilled water, dissolved in a minimum of 30% perchloric acid, made to 100 ml. with 50% TISAB, transferred to a plastic beaker, placed on a magnetic stirrer, and the electrodes inserted into the stirred solution. The solution was insulated from the heat of the stirrer with a half inch of sponge and the millivolt (MV) reading was recorded after the electrodes had equilibrated.

Immediately prior to sample analysis, the

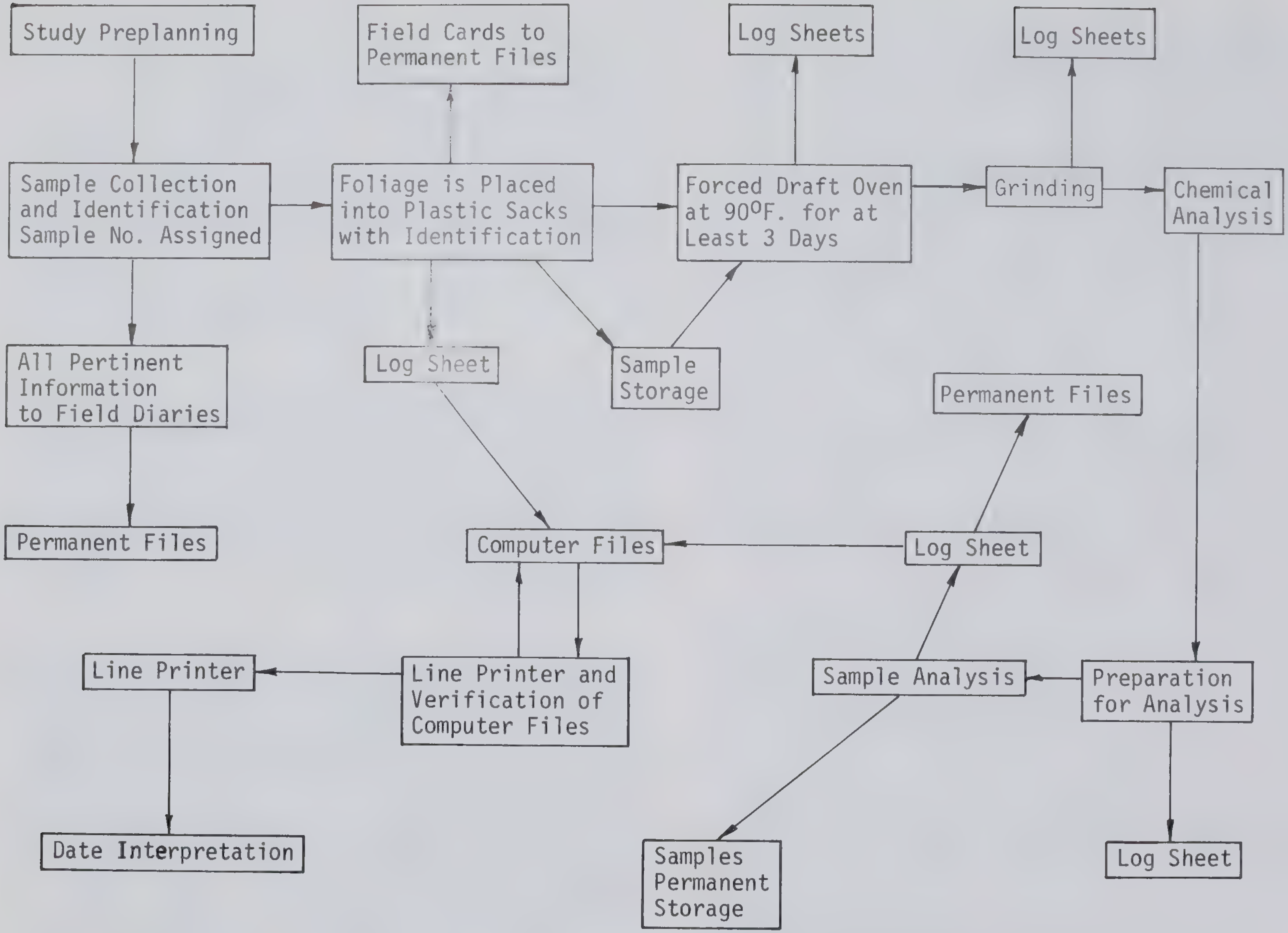

Study Preplanning
Field Cards to Permanent Files
Log Sheets
Log Sheets
Sample Collection and Identification Sample No. Assigned
Foliage is Placed into Plastic Sacks with Identification
Forced Draft Oven at 90°F. for at Least 3 Days
Grinding
Chemical Analysis
All Pertinent Information to Field Diaries
Log Sheet
Sample Storage
Permanent Files
Permanent Files
Computer Files
Log Sheet
Line Printer
Line Printer and Verification of Computer Files
Sample Analysis
Preparation for Analysis
Date Interpretation
Samples Permanent Storage
Log Sheet

FIGURE 10-29

electrodes were calibrated with standard solutions of the following fluoride concentrations: 0.05, 0.10, 0.50, 1.0, 5.0, 10.0, and 19.0 ppm. A calibration curve was prepared by plotting the millivolt reading as a function of fluoride concentration on semilogarithmic graph paper, and the fluoride content of unknowns was determined by interpolation from the graph and the following calculation:

$$\text{ppm } F^- = \frac{\text{ug}F^-/\text{ml}}{\text{Sample Wt. in g.}} \times 100$$

Samples with fluoride concentrations falling below the useful range of the calibration curve were treated by adding sufficient fluoride to bring them into the millivolt range. For most plant materials, 1 ml. of a 5.0 ppm F^- solution was sufficient. Reagent blanks were carried through the entire procedure with each series of samples.

As an alternative to the manual determination of fluoride concentration of unknowns, the preparation of the calibration curve, the interpolation, and the calculation of the fluoride concentration of unknown samples may be computerized.

3. Sulfur Analysis of Vegetation

The total sulfur (S) content of vegetation was determined by a combustion iodometric procedure employing a Leco induction furnace to generate SO_2 and titrating the SO_2 with potassium iodate (A.S.T.M. E30-47). An aliquot of dried, ground plant material was weighed into a crucible, tin and iron metal catalysts were added, and the crucible was placed into the furnace induction field. The sample was combusted in an oxygen atmosphere to generate SO_2 which was bubbled through a solution of iodine and starch. Sulfur dioxide generated in the furnace bleaches the solution of starch and free iodine by the following reaction:

$$SO_2 + I_2 + H_2O \rightarrow H_2SO_4 + 2HI$$

The blue color was maintained by titrating the starch solution with potassium iodate:

$$KIO_3 + 5KI + 6HCl \rightarrow 6KCl + 3I_2$$

The titration continued until SO_2 generation was completed, as evidenced by the maintenance of blue color in the starch solution without adding KIO_3.

a. Recovery Studies

In order to determine recovery efficiency of the combustion iodometric method for the analysis of total sulfur in plant material, three separate experiments were performed. First, aliquots of potassium aluminum sulfate were analyzed (Table 10-39). Second, known amounts of thiourea (NH_2CSNH_2) were adsorbed onto cellulose to give varying concentrations of sulfur in cellulose,

TABLE 10-39

RESULTS OF ANALYSES OF POTASSIUM ALUMINUM SULFATE ($KAl(SO_4)_2$) AS THE SOURCE OF SULFUR FOR SO_2 GENERATION

Grams S x 10^{-5} Added	Grams S x 10^{-5} Recovered
46.5	43
46.5	43
46.5	47
36.4	33
30	29
30.3	29
24.8	22
24.2	21
24.6	13
17.8	16
18.2	16
13.5	13
10.7	11
9.4	9
10	9

and these standards were then analyzed (Table 10-40). Finally, cellulose standards and plant samples were mixed to determine the effect of plant material on the recovery of sulfur from the standards (Table 10-41). Sample aliquots of 0.1 g. were used to obtain the data for Tables 10-40 and 10-41, since preliminary work had shown that such aliquots of plant material resulted in good combustion without violence and ready conversion to percent sulfur in the sample. The data in Table 10-41 show that the lowest recoveries were obtained with the largest volume of plant material and the smallest volume of cellulose-thiourea.

The average sulfur content of ponderosa pine foliage collected away from areas subjected to sulfurous air pollution has been previously reported. Katz and McCallum (1939) report average sulfur concentrations of .09 to .13%. Thomas et al. (1950) reported average sulfur content in different year's foliage of conifers ranging from .10 to .11%, and they indicate that organic sulfur in conifers normally is about .1%. The data of Keiley and Lambert (1972) indicate that sulfate-sulfur in the foliage of Monterey pine averages less than .025%.

In view of the above, it appears that species of pine found away from sources of sulfurous air pollution may contain most of their sulfur as organic sulfur and possibly less than 250 ppm of their total sulfur as inorganic sulfur. Therefore, the efficiency of recovery for the combustion iodometric method used in this study was based upon the results of recovery studies employing cellulose-thiourea standard and plant sample mixtures.

Because the lowest recoveries were obtained with the largest amount of plant material relative to the cellulose standard (Table 10-41), a graph was prepared (Figure 10-30) from which a given analysis of plant material could be increased by an amount of sulfur reflecting the low recovery. The recovery results of 2200 ppm S for a 2500 ppm concentration, and 700 ppm S for a 1000 ppm concentration were used to prepare Figure 10-30. Thus, if a given analysis of plant material resulted in a concentration of 1500 ppm S (X-axis, Figure 10-30), the result to be reported is 1800 ppm S (Y-axis, Figure 10-30).

b. Method of Sulfur Analysis

Weigh 0.10 g. of dried, ground plant material into a combustion crucible, add one scoop of iron and two scoops of tin metal. Add starch and HCl to the titration vessel, and titrate KIO_3 until the endpoint blue color is reached. Record the burette reading. Cover the crucible and place it in the induction furnace. Titrate with KIO_3 to keep the endpoint blue color until the solution is no longer bleached. Record the resultant burette reading. Determine the total sulfur content by use of Equations I and II below. Report the results as ppm S.

TABLE 10-40

RESULTS OF SULFUR RECOVERY FROM SYNTHETIC PLANT STANDARDS PONDEROSA PINE MIXTURES

Ppm S in Cellulose	Weight (g) Cellulose	Weight (g) P. Ponderosa	Ppm S Recovered	Average
2500	.025	.075	2000	2200
"	.025	.075	2400	
2500	.05	.05	2700	2433
"	.05	.05	2500	
"	.05	.05	2100	
1500	.05	.05	1500	1366
"	.05	.05	1400	
"	.05	.05	1200	
1000	.01	.09	800	700
"	.01	.09	700	
"	.01	.09	600	
500	.05	.05	500	500
"	.05	.05	500	

TABLE 10-41

RESULTS OF ANALYSES OF SYNTHETIC PLANT STANDARDS PREPARED BY ADSORBING THIOUREA ON PURE CELLULOSE

Ppm S Concentration in Cellulose-Thiourea	Ppm S Concentration in Cellulose-Thiourea Recovered by Analysis	Average
10000	9200	9200
5000	4700	4666
	4600	
	4700	
3000	2800	2866
	2800	
	3000	
2500	2300	2333
	2400	
	2300	
1500	1500	1433
	1500	
	1300	
1000	900	933
	1000	
	900	
500	500	533
	500	
	600	
0	0	0
	0	
	0	

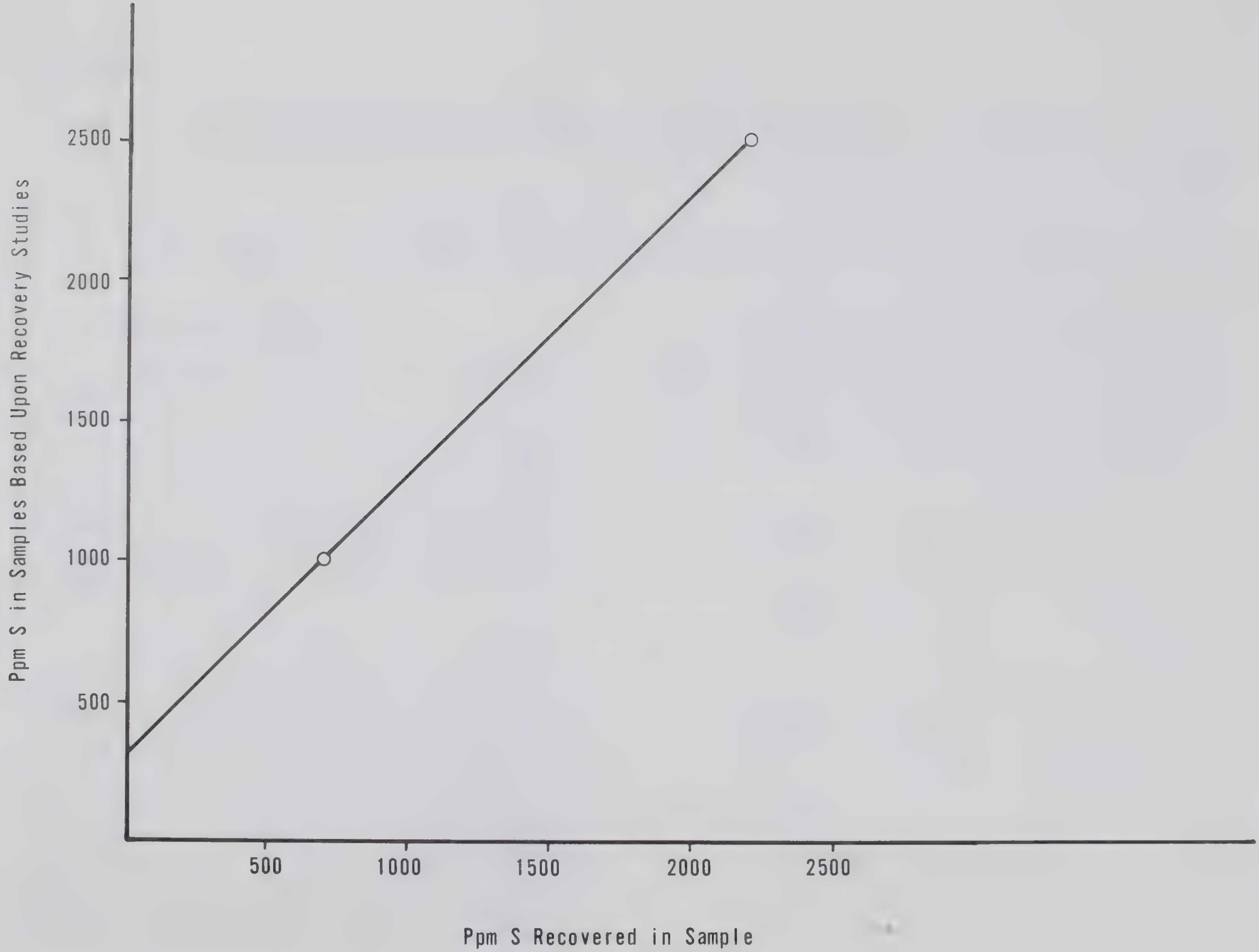

Ppm S in Samples Based Upon Recovery Studies
2500
2000
1500
1000
500
500
1000
1500
2000
2500
Ppm S Recovered in Sample

FIGURE 10-30

Equation I:

Percent S = (Final Burette Reading-Initial Burette Reading) - Blank

Equation II:

Ppm S = (Percent S)(10^4) + Increase from Figure 10-30

B. Chemical Analysis Results

The average, high and low results of all chemical analyses performed on vegetation for this study are shown in Table 10-42. The data are presented by sampling site with all sites showing fluoride (F^-) analysis results. Samples from some sites also were analyzed for sulfur (S) content. Therefore, the S analysis results are presented after the F^- results for those individual sites. Scientific names of all plant species are presented in Appendix D2.

As regards F^-, the means of all species for collection sets one or two were below 5 ppm F^-, except for Indian ricegrass which was 7.27 ppm F^-. No significant difference between the F^- concentrations of shrubs and grasses was found, but ponderosa pine was significantly lower in F^- concentration. A significant reduction in F^- concentration in the spring 1974 ponderosa pine collection over the fall 1973 collection was found. However, there was a significant general tendency for the older needles to accumulate greater concentrations of F^- than the younger needles.

The mean total S concentration did not exceed 900 ppm at any sampling site. A significant general increase in total S concentration with the older needles could not be shown. However, a significant decrease was shown in the mean total S content of the spring 1974 collection from that of the fall 1973 collection.

Conclusions: The Colstrip study area is a superb "control" area for total S in ponderosa pine and for F^- in grasses, shrubs, and ponderosa pine. Further, both S and F^- increase in the vegetation of the area during the growing seasons, but decrease during the dormant period.

TABLE 10-42

FLUORIDE AND SULFUR GROUP MEANS FOR VEGETATION BY LOCATION

Site #	Species	Year of Foliage	No. of Data	ppm F- Average	ppm F- High	ppm F- Low
N1	Ponderosa pine	70	10	2.3	4.6	0.9
	"	71	10	2.0	3.1	0.9
	"	72	10	2.5	7.1	0.9
	"	73	10	2.3	4.3	0.4
	Rocky Mountain juniper	Composite	4	2.1	3.6	0.8
	Silver sagebrush	Composite	5	3.8	4.0	3.6
	Little bluestem	Composite	5	3.0	4.6	1.9
	Bluebunch wheatgrass	Composite	5	2.5	4.0	0.5
	Horizontal juniper	Composite	1	2.7	-	-
N2	Ponderosa pine	70	10	1.8	3.7	.4
	"	71	10	1.4	3.0	0.5
	"	72	10	1.7	3.9	0.6
	"	73	10	1.8	3.2	0.6
	Rocky Mountain juniper	Composite	5	3.3	4.5	2.3
	Big sagebrush	Composite	5	4.7	6.4	4.0
	Bluebunch wheatgrass	Composite	5	5.3	6.9	2.2

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
N2 (cont.)	Little bluestem	Composite	4	3.5	5.2	2.1
	Red three-awn	Composite	1	4.1	-	-
N3	Rocky Mountain juniper	Composite	5	1.5	3.0	0.7
	Big sagebrush	Composite	5	2.5	4.2	1.0
	Silver sagebrush	Composite	2	1.7	2.3	1.1
	Bluebunch wheatgrass	Composite	5	2.4	5.3	0.8
	Little bluestem	Composite	5	1.4	2.2	1.0
	Soapweed	Composite	3	0.9	1.2	0.8
N4	Ponderosa pine	70	10	2.0	4.5	0.4
	"	71	10	2.6	7.9	0.6
	"	72	10	2.9	13.2	0.6
	"	73	10	1.4	2.4	0.3
	Rocky Mountain juniper	Composite	3	4.1	9.0	2.0
	Skunkbush sumac	Composite	3	3.8	6.5	2.8
	Bluebunch wheatgrass	Composite	6	5.0	11.2	2.0

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F- Average	High	Low
N4 (cont.)	Indian ricegrass	Composite	2	9.3	13.5	5.1
	Silver sagebrush	Composite	4	2.7	3.7	1.6
	Little bluestem	Composite	1	2.8	-	-
NE1	Ponderosa pine	70	10	1.6	2.3	0.8
	"	71	10	2.1	3.4	1.1
	"	72	10	1.7	2.7	1.1
	"	73	10	1.6	2.6	0.8
	Rocky Mountain juniper	Composite	5	2.7	4.6	1.8
	Silver sagebrush	Composite	5	2.8	4.8	1.2
	Bluebunch wheatgrass	Composite	5	2.8	3.3	2.3
	Little bluestem	Composite	4	2.2	3.0	1.2
	Big sagebrush	Composite	1	1.6	-	-
NE2	Ponderosa pine	70	10	1.4	2.5	0.7
	"	71	10	1.7	2.9	0.4
	"	72	10	1.3	3.5	0.3

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
NE2 (cont.)	Ponderosa pine	73	10	0.9	1.4	0.3
	Rocky Mountain juniper	Composite	5	1.8	2.4	1.3
	Big sagebrush	Composite	3	2.9	4.1	2.0
	Bluebunch wheatgrass	Composite	5	5.9	14.7	2.7
	Little bluestem	Composite	4	3.1	4.5	0.8
	Rubber rabbitbrush	Composite	2	2.9	4.0	1.7
	Prairie sandreed	Composite	1	1.3	-	-
NE3	Ponderosa pine	70	10	2.2	2.9	1.5
	"	71	10	2.1	3.1	0.6
	"	72	10	1.5	2.1	0.8
	"	73	10	1.9	2.7	0.9
	Rocky Mountain juniper	Composite	5	2.5	3.5	1.5
	Silver sagebrush	Composite	2	4.4	5.6	3.2
	Bluebunch wheatgrass	Composite	5	8.3	13.2	2.6
	Little bluestem	Composite	5	4.8	10.4	2.2

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
NE3 (cont.)	Rubber rabbitbrush	Composite	1	2.7	-	-
	Big Sagebrush	Composite	2	3.4	5.0	1.8
				ppm S		
				Average	High	Low
	Ponderosa pine	70	10	700	900	500
	"	71	10	740	1000	500
	"	72	10	760	1000	500
	"	73	10	680	800	500
				ppm F-		
				Average	High	Low
NE4	Little bluestem	Composite	4	4.4	5.3	3.1
	Big sagebrush	Composite	5	4.1	5.6	1.2
	Bluebunch wheatgrass	Composite	5	5.7	7.9	4.1
	Silver sagebrush	Composite	5	4.4	5.5	3.0
	Needle-&-thread	Composite	6	4.0	5.7	2.4

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Foliage	Data	ppm F- Average	High	Low
E1	Ponderosa pine	70	10	2.2	3.1	0.8
	"	71	10	2.5	5.5	0.7
	"	72	10	2.5	3.5	1.5
	"	73	10	1.7	4.3	0.8
	Rocky Mountain juniper	Composite	4	1.7	2.9	0.6
	Bluebunch wheatgrass	Composite	5	2.6	6.5	1.0
	Little bluestem	Composite	5	1.4	2.0	0.8
	Prairie sandreed	Composite	4	1.2	1.9	0.2
	Silver sagebrush	Composite	1	4.4	-	-
	Red three-awn	Composite	1	0.9	-	-
E2	Ponderosa pine	70	10	1.5	4.0	0.1
	"	71	10	2.1	4.1	1.3
	"	72	10	1.6	3.6	0.3
	"	73	10	1.4	2.1	0.5
	Rocky Mountain juniper	Composite	7	4.4	13.4	1.8
	Bluebunch wheatgrass	Composite	6	5.1	7.9	2.1

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Foliage	Data	ppm F-		
				Average	High	Low
E2 (cont.)	Big sagebrush	Composite	2	5.0	5.2	4.8
	Little bluestem	Composite	4	2.0	3.5	1.3
	Silver sagebrush	Composite	1	3.9	-	-
				ppm S		
				Average	High	Low
	Ponderosa pine	70	5	900	1000	800
	"	71	5	920	1100	800
	"	72	5	860	1000	800
	"	73	5	845	1000	800
				ppm F-		
				Average	High	Low
E3	Ponderosa pine	70	10	1.9	3.3	0.6
	"	71	10	1.5	2.5	0.4
	"	72	10	1.5	2.2	0.6
	"	73	10	1.0	2.1	0.3

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
E3 (cont.)	Rocky Mountain juniper	Composite	5	0.6	0.9	0.4
	Skunkbush sumac	Composite	5	1.0	2.1	0.4
	Bluebunch wheatgrass	Composite	5	1.5	2.8	0.3
	Little bluestem	Composite	5	0.8	2.3	0.3
E4	Ponderosa pine	70	10	3.6	7.5	1.6
	"	71	10	2.9	7.1	1.3
	"	72	10	3.1	8.7	0.5
	"	73	10	2.5	6.9	0.8
	Big sagebrush	Composite	5	4.1	6.8	2.1
	Rubber rabbitbrush	Composite	2	3.7	5.3	2.0
	Bluebunch wheatgrass	Composite	5	3.9	8.3	1.9
	Little bluestem	Composite	5	5.3	7.3	2.7
	Skunkbush sumac	Composite	3	7.6	8.8	6.7

				ppm S		
				Average	High	Low
	Ponderosa pine	70	10	850	1200	700

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm S		
				Average	High	Low
E4 (cont.)	Ponderosa pine	71	10	790	1000	600
	"	72	10	830	1000	600
	"	73	10	790	900	700
				ppm F-		
				Average	High	Low
E5	Ponderosa pine	70	10	1.2	2.4	0.2
	"	71	10	1.4	2.5	0.6
	"	72	10	1.2	2.8	0
	"	73	10	0.9	1.9	0.5
	Rocky Mountain juniper	Composite	5	3.2	8.8	0.9
	Little bluestem	Composite	5	2.6	6.4	0.8
	Bluebunch wheatgrass	Composite	5	2.8	8.2	0.3
	Red three-awn	Composite	1	3.6	-	-
	Silver sagebrush	Composite	1	1.9	-	-
	Prairie sandreed	Composite	1	0.3	-	-
	Skunkbush sumac	Composite	2	1.5	2.5	0.4

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm S		
				Average	High	Low
E5 (cont.)	Ponderosa pine	70	10	850	1000	700
	"	71	10	830	1000	700
	"	72	10	850	1000	700
	"	73	10	810	1000	700
				ppm F-		
				Average	High	Low
SE1	Ponderosa pine	70	10	1.5	2.9	0.2
	"	71	10	1.7	4.8	0.6
	"	72	10	1.3	2.6	0
	"	73	10	1.3	3.2	0.5
	Rocky Mountain juniper	Composite	5	2.2	3.8	1.4
	Silver sagebrush	Composite	1	2.2	-	-
	Little bluestem	Composite	5	1.8	2.9	0.8
	Bluebunch wheatgrass	Composite	6	2.0	3.6	0.8
	Prairie sandreed	Composite	3	2.6	5.8	0.9

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm S		
				Average	High	Low
SE1 (cont.)	Ponderosa pine	70	10	710	900	500
	"	71	10	740	900	600
	"	72	10	740	900	600
	"	73	10	730	900	500

				ppm F-		
				Average	High	Low
SE2	Ponderosa pine	70	10	1.6	2.6	0.3
	"	71	10	0.7	1.2	0.4
	"	72	10	1.6	2.7	0.3
	"	73	10	1.3	3.8	0.5
	Silver sagebrush	Composite	5	2.1	3.9	1.1
	Big sagebrush	Composite	1	6.1	-	-
	Little bluestem	Composite	5	3.9	6.1	0.7
	Bluebunch wheatgrass	Composite	5	1-6	2.8	0.5
	Green rabbitbrush	Composite	1	4.2	-	-
	Rocky Mountain juniper	Composite	2	3.1	4.4	1.8
	Prairie sandreed	Composite	1	0.5	-	-

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm S		
				Average	High	Low
SE2 (cont.)	Ponderosa pine	70	10	750	1100	600
	"	71	10	760	1000	600
	"	72	10	780	1000	600
	"	73	10	840	1200	700
				ppm F-		
				Average	High	Low
SE3	Ponderosa pine	70	10	3.2	5.0	0.3
	"	71	10	3.0	5.8	0.3
	"	72	10	2.6	3.7	0.5
	"	73	10	2.3	4.3	0.7
	Skunkbush sumac	Composite	7	3.2	5.8	1.1
	Bluebunch wheatgrass	Composite	5	1.6	2.7	0.6
	Needle-&-thread	Composite	5	2.6	4.9	0.2
	Green rabbitbrush	Composite	3	4.3	5.4	2.8

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm S		
				Average	High	Low
SE3 (cont.)	Ponderosa pine	70	10	760	1000	600
	"	71	10	790	1100	500
	"	72	10	760	1200	500
	"	73	10	720	900	500
				ppm F-		
				Average	High	Low
SE4	Ponderosa pine	70	10	2.4	4.3	0.8
	"	71	10	2.2	3.9	0.7
	"	72	10	2.2	4.4	1.0
	"	73	10	2.2	6.0	0.2
	Skunkbush sumac	Composite	5	1.1	2.2	0.8
	Chokecherry	Composite	1	1.2	-	-
	Bluebunch wheatgrass	Composite	5	1.9	3.5	0.3
	Little bluestem	Composite	5	1.3	2.6	0.5
	Rocky Mountain juniper	Composite	2	1.3	1.4	1.1
	Silver sagebrush	Composite	2	1.9	2.1	1.6

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm S		
				Average	High	Low
SE4 (cont.)	Ponderosa pine	70	10	810	1000	700
	"	71	10	780	900	700
	"	72	10	840	1000	700
	"	73	10	830	900	700
				ppm F-		
				Average	High	Low
SE5	Ponderosa pine	70	10	3.6	6.1	1.8
	"	71	10	2.8	4.9	1.7
	"	72	10	3.0	5.3	1.7
	"	73	10	3.2	4.6	2.1
	Bluebunch wheatgrass	Composite	4	5.8	8.8	3.1
	Little bluestem	Composite	5	3.8	5.9	1.3
	Skunkbush sumac	Composite	3	6.6	8.9	5.4
	Fringed sage	Composite	1	5.0	-	-
	Big sagebrush	Composite	3	6.0	6.8	5.5
	Silver sagebrush	Composite	1	4.3	-	-

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
SE5 (cont.)	Rubber rabbitbrush	Composite	1	3.1	-	-
				ppm S		
				Average	High	Low
	Ponderosa pine	70	10	720	1100	600
	"	71	10	760	1100	500
	"	72	10	740	1100	1200
	"	73	10	700	1100	500
				ppm F-		
				Average	High	Low
S1	Ponderosa pine	70	10	2.2	5.4	0.4
	"	71	10	1.7	4.5	0.5
	"	72	10	1.6	4.7	0.7
	"	73	10	1.9	5.4	0.3
	Silver sagebrush	Composite	1	5.0	-	-
	Rocky Mountain juniper	Composite	5	3.8	4.8	2.3
	Bluebunch wheatgrass	Composite	5	8.3	11.8	2.5
	Little bluestem	Composite	5	6.3	12.4	3.4

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Foliage	No. of Data	ppm F- Average	High	Low
S1 (cont.)	Big sagebrush	Composite	3	7.3	9.6	5.3
	Rubber rabbitbrush	Composite	1	5.8	-	-
S2	Ponderosa pine	70	10	2.3	5.1	0.3
	"	71	10	2.3	4.7	0.7
	"	72	10	1.8	3.9	0.1
	"	73	10	1.5	4.7	0.4
	Rocky Mountain juniper	Composite	8	2.6	5.6	0.8
	Bluebunch wheatgrass	Composite	5	1.7	2.7	0.9
	Little bluestem	Composite	5	1.5	2.1	0.7
	Silver sagebrush	Composite	2	3.8	4.0	3.5
S3	Ponderosa pine	70	10	1.8	2.7	0.8
	"	71	10	1.2	2.6	0.3
	"	72	10	1.5	3.6	0.3
	"	73	10	1.4	2.8	0.2
	Skunkbush sumac	Composite	6	2.7	3.9	0.7

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
S3 (cont.)	Bluebunch wheatgrass	Composite	7	2.1	3.3	1.4
	Chokecherry	Composite	3	1.6	2.3	0.6
	Little bluestem	Composite	3	1.4	2.3	0.1
	Rocky Mountain juniper	Composite	1	2.6	-	-
				ppm S		
				Average	High	Low
	Ponderosa pine	70	10	650	800	500
	"	71	10	640	800	500
	"	72	10	630	700	500
	"	73	10	650	800	500
				ppm F-		
				Average	High	Low
S4	Ponderosa pine	70	10	2.1	4.7	0.8
	"	71	10	2.1	4.8	0.7
	"	72	10	1.9	4.9	0.1
	"	73	10	1.7	4.7	0.5

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Foliage	No. of Data	ppm F- Average	High	Low
S4 (cont.)	Rocky Mountain juniper	Composite	5	2.5	4.2	0.1
	Big sagebrush	Composite	5	3.4	4.8	1.7
	Bluebunch wheatgrass	Composite	8	3.2	7.9	0.4
	Idaho fescue	Composite	1	2.6	-	-
	Needle-&-thread	Composite	1	3.3	-	-
SW1	Ponderosa pine	70	10	2.2	3.5	1.4
	"	71	10	1.8	3.3	0.4
	"	72	10	1.6	3.5	0.2
	"	73	10	1.5	2.8	0.3
	Rocky Mountain juniper	Composite	6	2.0	3.6	0.7
	Big sagebrush	Composite	2	5.6	6.6	4.5
	Bluebunch wheatgrass	Composite	5	1.2	2.6	0.3
	Little bluestem	Composite	5	2.6	7.9	0.2
	Silver sagebrush	Composite	2	2.7	2.7	2.6
SW2	Ponderosa pine	70	10	1.8	3.3	0.5

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F- Average	High	Low
SW2 (cont.)	Ponderosa pine	71	9	1.4	3.4	0.3
	"	72	10	1.5	3.3	0.3
	"	73	10	1.4	2.5	0.3
	Rocky Mountain juniper	Composite	5	1.6	3.3	0.3
	Bluebunch wheatgrass	Composite	4	1.9	2.7	1.4
	Little bluestem	Composite	5	2.4	3.8	0.8
	Silver sagebrush	Composite	4	1.9	2.1	1.6
	Soapweed	Composite	1	0.3	-	-
SW3	Ponderosa pine	70	8	1.6	3.1	0.8
	"	71	10	1.9	3.4	0.8
	"	72	10	1.5	2.2	0.7
	"	73	10	1.6	2.4	0.6
	Big sagebrush	Composite	2	3.8	5.7	1.9
	Rubber rabbitbrush	Composite	3	4.0	4.5	2.9
	Bluebunch wheatgrass	Composite	7	8.1	12.9	3.7
	Skunkbush sumac	Composite	4	3.2	4.4	1.9

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
SW3 (cont.)	Prairie sandreed	Composite	1	1.9	-	-
	Needle-&-thread	Composite	1	2.0	-	-
	Silver sagebrush	Composite	1	1.5	-	-
	Little bluestem	Composite	1	2.8	-	-
				ppm S		
				Average	High	Low
	Ponderosa pine	70	8	1025	1700	900
	"	71	10	1000	1700	800
	"	72	10	1010	1700	700
	"	73	10	950	1500	600
				ppm F-		
				Average	High	Low
SW4	Snowberry	Composite	2	3.0	3.5	2.5
	Thorny buffaloberry	Composite	1	4.5	-	-
	Kentucky bluegrass	Composite	2	2.9	2.9	2.8
	Prairie sandreed	Composite	1	2.6	-	-

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
SW4 (cont.)	Black cottonwood	Composite	1	2.0	-	-
	Big sagebrush	Composite	3	3.7	4.0	3.8
	Greasewood	Composite	1	4.1	-	-
	Bluebunch wheatgrass	Composite	4	3.7	5.7	2.7
	Chokecherry	Composite	1	3.3	-	-
	Silver sagebrush	Composite	3	3.7	5.7	2.6
	Needle-&-thread	Composite	3	4.1	5.0	2.9
	Prairie junegrass	Composite	1	3.6	-	-
	Fringed sage	Composite	2	3.0	3.5	2.5
W1	Ponderosa pine	70	10	1.4	3.1	0.2
	"	71	10	1.4	2.6	0.8
	"	72	10	0.9	2.0	0.2
	"	73	10	1.2	2.2	0.4
	Silver sagebrush	Composite	5	3.5	4.4	2.3
	Rocky Mountain juniper	Composite	5	3.9	5.6	4.3
	Little bluestem	Composite	5	1.8	2.7	1.1

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
W1 (cont.)	Bluebunch wheatgrass	Composite	5	2.4	3.0	1.9
				ppm S		
				Average	High	Low
	Ponderosa pine	70	10	790	1000	600
	"	71	10	770	900	600
	"	72	10	870	1000	700
	"	73	10	770	900	600
				ppm F-		
				Average	High	Low
W2	Ponderosa pine	70	10	2.4	5.1	0.4
	"	71	10	2.4	6.0	0.5
	"	72	10	1.9	5.1	0.2
	"	73	10	1.9	3.2	0.6
	Rocky Mountain juniper	Composite		2.6	3.3	1.4
	Bluebunch wheatgrass	Composite	6	1.8	3.8	0.1
	Little bluestem	Composite	7	1.4	2.6	0.4

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
W2 (cont.)	Green rabbitbrush	Composite	1	2.2	-	-
	Prairie sandreed	Composite	1	1.2	-	-
				ppm S		
				Average	High	Low
	Ponderosa pine	70	10	780	1000	600
	"	71	10	800	1000	600
	"	72	10	780	1000	500
	"	73	10	790	900	600
				ppm F-		
				Average	High	Low
W3	Ponderosa pine	70	10	1.3	2.2	0.2
	"	71	10	1.3	2.7	0.3
	"	72	10	1.5	3.9	0.7
	"	73	10	0.9	1.9	0.3
	Rocky Mountain juniper	Composite	6	2.0	2.7	1.0
	Silver sagebrush	Composite	2	1.8	2.1	1.4

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F- Average	ppm F- High	ppm F- Low
W3 (cont.)	Bluebunch wheatgrass	Composite	9	1.2	2.3	0.4
	Soapweed	Composite	2	1.0	0.9	1.0
				ppm S Average	High	Low
	Ponderosa pine	70	10	760	900	600
	"	71	10	790	900	600
	"	72	10	840	1000	700
	"	73	10	820	1000	600
				ppm F- Average	High	Low
W4	Ponderosa pine	70	10	1.8	2.9	0.4
	"	71	10	1.6	3.5	0.4
	"	72	10	1.4	5.2	0
	"	73	10	1.3	3.4	0.1
	Skunkbush sumac	Composite	5	3.2	4.3	1.0
	Silver sagebrush	Composite	5	3.1	5.5	0.7

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F- Average	ppm F- High	ppm F- Low
W4 (cont.)	Little bluestem	Composite	5	2.9	6.2	1.1
	Bluebunch wheatgrass	Composite	5	6.2	10.5	4.0
				ppm S		
				Average	High	Low
	Ponderosa pine	70	10	830	1000	700
	"	71	10	800	900	800
	"	72	10	870	1100	600
	"	73	10	840	1000	700
				ppm F-		
				Average	High	Low
NW1	Ponderosa pine	70	9	1.1	2.3	0.4
	"	71	9	1.2	3.4	0.3
	"	72	9	1.2	3.1	0.3
	"	73	9	1.3	3.5	0.4
	Silver sagebrush	Composite	5	2.3	3.0	
	ebrush	Composite	1	2.0		

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
NW1 (cont.)	Little bluestem	Composite	5	1.8	3.4	0.5
	Bluebunch wheatgrass	Composite	5	2.2	3.4	1.0
	Rocky Mountain juniper	Composite	3	2.2	3.2	1.1
	Prairie sandreed	Composite	1	2.1	-	-
NW2	Ponderosa pine	70	10	2.2	4.1	0.8
	"	71	10	1.6	3.2	0.7
	"	72	10	1.7	3.1	0.3
	"	73	10	1.4	3.9	0.4
	Rocky Mountain juniper	Composite	5	2.7	3.2	1.8
	Big sagebrush	Composite	1	8.4	-	-
	Bluebunch wheatgrass	Composite	5	8.5	18.4	3.2
	Little bluestem	Composite	5	4.0	5.8	2.4
	Rubber rabbitbrush	Composite	3	5.4	5.7	5.0
NW3	Ponderosa pine	70	8	2.5	3.6	0.7
	"	71	10	1.7	3.1	0.1

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F- Average	High	Low
NW3 (cont.)	Ponderosa pine	72	10	2.3	6.4	0.2
	"	73	10	2.7	2.8	1.1
	Rocky Mountain juniper	Composite	4	1.4	2.2	0.5
	Big sagebrush	Composite	2	3.2	3.5	2.8
	Bluebunch wheatgrass	Composite	5	3.1	5.5	1.7
	Red three-awn	Composite	3	3.3	4.5	2.0
	Silver sagebrush	Composite	4	2.7	3.4	1.6
	Little bluestem	Composite	1	0.4	-	-
	Prairie sandreed	Composite	1	0.6	-	-
NW4	Ponderosa pine	70	10	2.2	4.0	0.3
	"	71	10	1.6	3.5	0.5
	"	72	10	2.3	3.5	1.2
	"	73	10	1.6	4.0	0.1
	Rocky Mountain juniper	Composite	3	2.0	2.8	1.3
	Skunkbush sumac	Composite	5	2.1	3.5	0.9
	Bluebunch wheatgrass	Composite	4	5.8	8.8	3.3

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
NW4 (cont.)	Little bluestem	Composite	5	4.9	5.3	1.5
	Silver sagebrush	Composite	2	2.1	2.2	1.9
	Prairie sandreed	Composite	1	9.6	-	-
				ppm S		
				Average	High	Low
	Ponderosa pine	70	10	890	1200	600
	"	71	10	890	1500	700
	"	72	10	910	1600	600
	"	73	10	910	1400	600
				ppm F-		
				Average	High	Low
NW5	Ponderosa pine	70	10	2.5	3.9	0.4
	"	71	10	2.0	4.6	0.2
	"	72	10	1.9	3.0	0.6
	"	73	10	1.7	3.6	0.5
	Rocky Mountain juniper	Composite	5	3.3	4.5	2.9

FLUORIDE AND SULFUR GROUP MEANS
(continued)

Site #	Species	Year of Foliage	No. of Data	ppm F-		
				Average	High	Low
NW5 (cont.)	Skunkbush sumac	Composite	2	4.2	4.5	3.9
	Indian ricegrass	Composite	1	3.2	-	-
	Bluebunch wheatgrass	Composite	4	5.8	8.4	1.6
	Little bluestem	Composite	4	4.8	7.4	3.1
	Prairie sandreed	Composite	2	4.4	5.4	3.3
	Silver sagebrush	Composite	2	2.6	3.3	1.9
				ppm S		
				Average	High	Low
	Ponderosa pine	70	10	850	1100	600
	"	71	10	850	1100	600
	"	72	10	830	1000	600
	"	73	10	870	1200	600

10.1.7. Wildlife

10.1.7.1. Mammals

A. Big Game

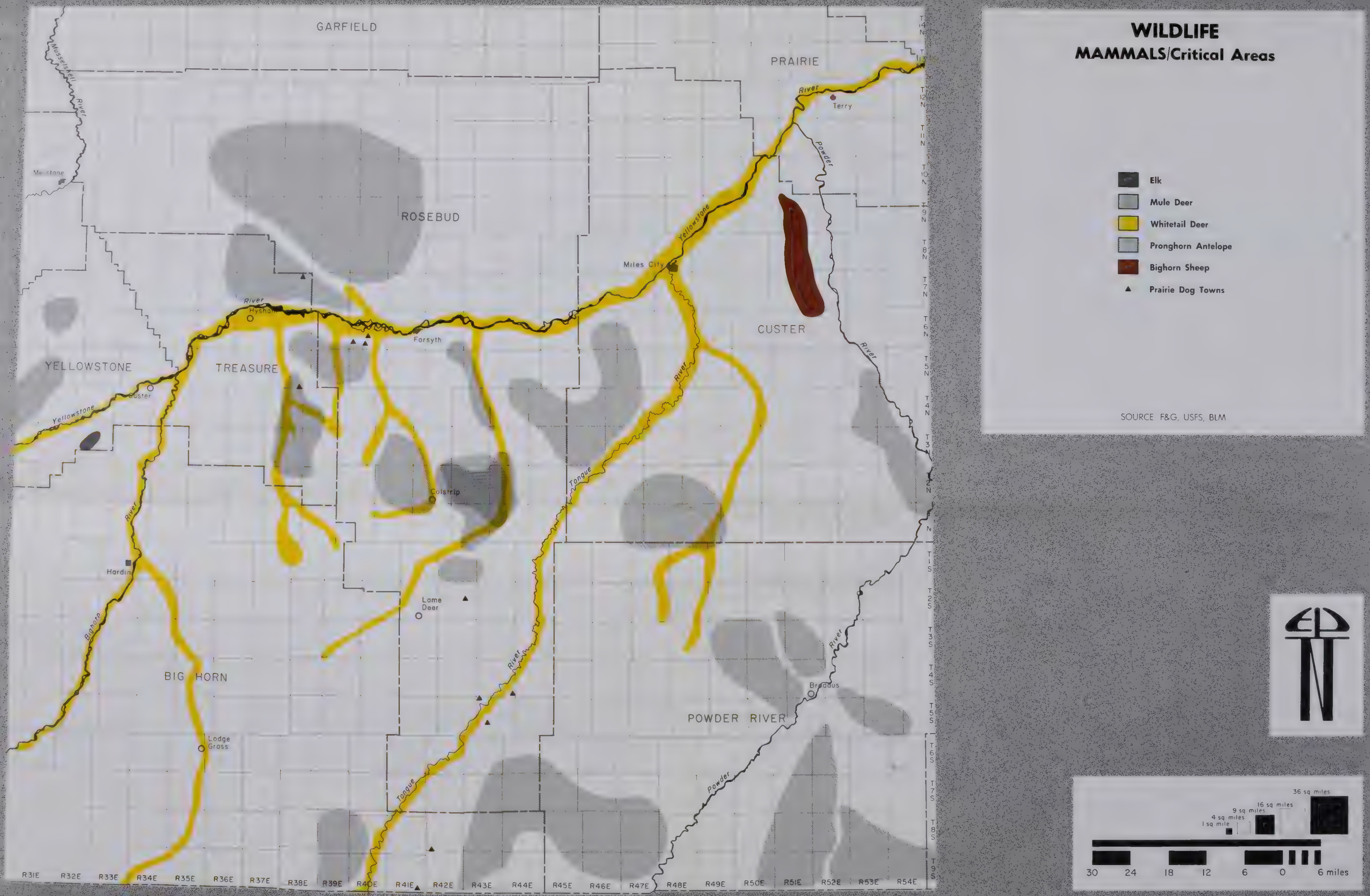
Important game mammals located in the Colstrip study area include mule deer (Odocoileus hemionus), white-tailed deer (Odocoileus virginianus), antelope (Antilocapra americana), and a small number of bighorn sheep (Ovis canadensis).

1. Mule Deer

Mule deer are found throughout the study area. During the field study (September 1973 to May 1974), 1,714 observations of mule deer were recorded from both ground and air surveys. High-density mule deer areas are shown on the Wildlife-Mammals Critical Areas Map. The 100-square-mile area east of Colstrip, between Armells and Rosebud Creeks and the Sarpy Creek drainage, appears to have excellent mule deer populations, with both density and productivity above average. Productivity for the entire study area with 92 to 94 fawns per 100 does (Table 10-43), is also excellent, since mule deer fawn/doe ratios exceeding 80 fawns per 100 does are considered good. These ratios were calculated during the fall from observations of deer made separately from ground vehicles and airplane.

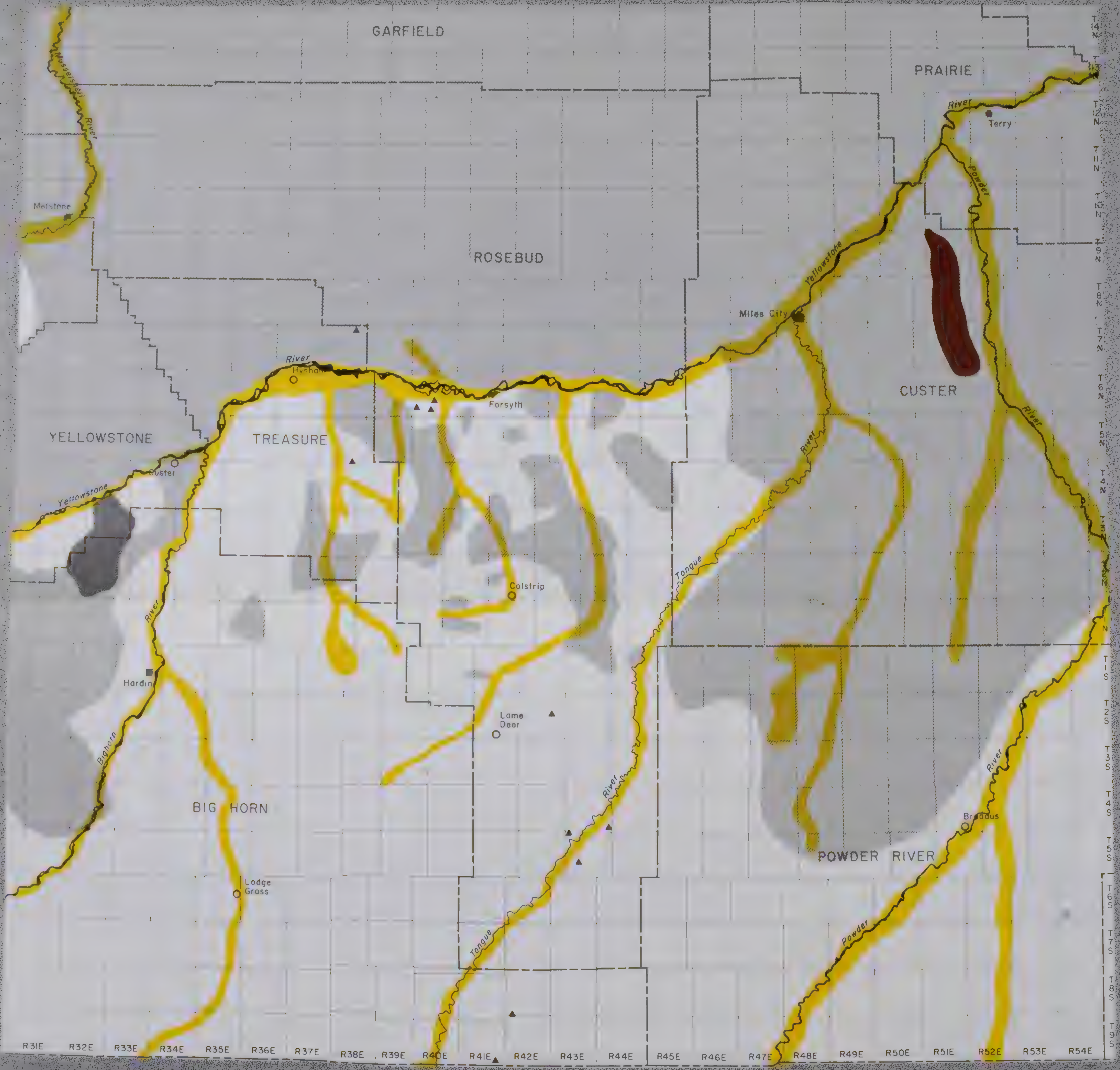
As can be seen from Table 10-43, winter ratios were comparable. Since bucks lose their antlers throughout winter, it becomes increasingly difficult to distinguish them from does, and too many adult animals may be classified as does. Because this would artificially lower the number of fawns per 100 does, fawn-to-adult ratios are used in winter. One hundred and thirty-seven winter ground observations of mule deer produced a ratio of 80 fawns per 100 adults, and 653 aerial observations produced a ratio of 72 fawns per 100 adults. These figures lend support to the high fawn/doe ratios obtained in the fall.

In southeastern Montana, deer are generally nonmigratory. There is a seasonal change of habitat types due to changes in weather and food habits. Deer observations were not made during summer. However, Knapp's (1972) summer work on the Custer National Forest, which is within the present Colstrip study area, found that almost 90% of the 668 deer observed were within the general ponderosa pine habitat type. About 10% were observed in the big sagebrush-grassland type and 1% in the grassland type. Mackie (1970), working in the Missouri River breaks, confirmed the summer importance to mule deer of the pine-juniper habitat type. The specific vegetation types deer appear to frequent most often during summer months are the pine forest, juniper, agricultural land and the skunkbush sumac-grassland hillsides. The pine forest and juniper appear to supply food and shelter, the agricultural land is a good source of food, and the skunkbush sumac-grassland hillsides supply an


WILDLIFE
MAMMALS/Critical Areas
Elk
Mule Deer
Whitetail Deer
Pronghorn Antelope
Bighorn Sheep
Prairie Dog Towns
SOURCE F&G, USFS, BLM
GARFIELD
PRAIRIE
ROSEBUD
CUSTER
YELLOWSTONE
TREASURE
BIG HORN
POWDER RIVER
Musselshell River
Melstone
Yellowstone River
Hysham
Forsyth
Miles City
Terry
Custer
Colstrip
Lame Deer
Hardin
Lodge Grass
Broadus
Bighorn River
Tongue River
Powder River
R31E R32E R33E R34E R35E R36E R37E R38E R39E R40E R41E R42E R43E R44E R45E R46E R47E R48E R49E R50E R51E R52E R53E R54E
T14N T13N T12N T11N T10N T9N T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S T4S T5S T6S T7S T8S T9S
36 sq miles
16 sq miles
9 sq miles
4 sq miles
1 sq mile
30 24 18 12 6 0 6 miles
N

WILDLIFE

MAMMALS/General Distribution



■ Elk

🟨 Whitetail Deer

□ Pronghorn Antelope

🟥 Bighorn Sheep

▲ Prairie Dog Towns

SOURCE F&G, USFS, BLM

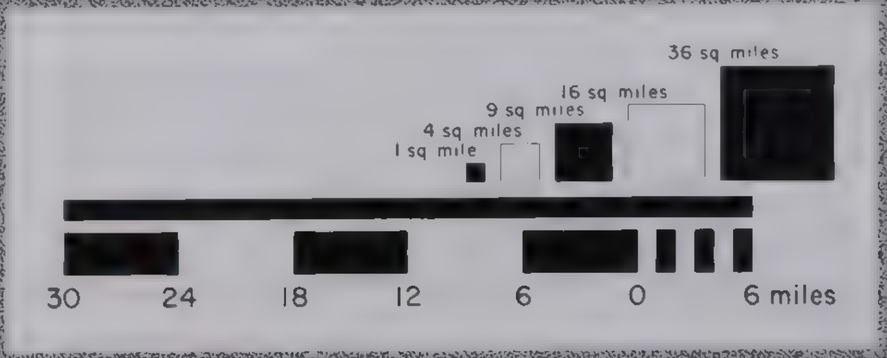


Table 10-43

Productivity Ratios of Mule Deer Observed from Vehicle and Airplane in the Colstrip Study Area

Type of Ratio	Number of Animals Observed 1/	Time Period	Productivity Ratios	Rating
Fawns/100 Does	324 (Air)	Jan. - March	92 F/100 Does	Excellent
Fawns/100 Does	70 (4WD)	Dec. - March	94 F/100 Does	Excellent
Fawns/100 Adults	653 (Air)	Jan. - March	72 F/100 Adults	Good
Fawns/100 Adults	137 (4WD)	Dec. - March	80 F/100 Adults	Good
Fawns/100 Does	102 (4WD)	Oct. - Nov.	92 F/100 Does	Excellent
Fawns/100 Does	172 (4WD)	Oct. - May	93 F/100 Does	Excellent

1/ (Air) or (4WD) indicates whether survey was made from airplane or 4-wheel drive vehicle.

important summer browse species, skunkbush sumac.

In fall, the use of agricultural land by mule deer reaches its annual peak, comprising 36% of the observations during this season (Table 10-44). Egan (1957) reached this same conclusion in a study on Otter Creek, which is within the Colstrip study area. The increased fall use of agricultural land probably occurs because of the desiccated condition of forbs at this time of year. Use of the big sagebrush-grassland type also begins to increase in fall. Mackie (1970) noticed the same trend which is probably related to the change in mule deer food habits to a more shrubby diet. Ecological Consulting Service (1973) biologists noted this trend in the Colstrip area.

Use of the big sagebrush-grassland type, including that within ponderosa pine openings, increases from 27% in fall to 44% in winter. Ponderosa pine openings supply the necessary winter forage and, at the same time, shelter and escape cover is nearby. Use of agricultural land is at its lowest during winter, while use of the ponderosa pine type (including openings) increases from 32% in fall to 71% in winter. This is probably due to the need for shelter during cold weather and the greater observability of deer during winter.

During spring, use of the big sagebrush-grassland remained high, and use of ponderosa pine forests and openings dropped from 71% to 26%. Use of agricultural lands increased from 4% to 22%.

Food habits of mule deer in the Colstrip study area vary considerably throughout the year (Table 10-45). In June and July forbs make up 55% of the diet, with common salsify, wild lettuce, and some alfalfa comprising the bulk. The only shrubs utilized during these months were rose and skunkbush sumac, which together averaged 43% of the diet. In August shrubs dominated the diet, with skunkbush, rose, and chokecherry together accounting for 67% of the diet. The only major forb used in August was alfalfa. It is typical for alfalfa use to reach its peak in August and/or September due to its continued succulence and the drying of the upland forbs. In September, skunkbush and dandelion were common in the diet, while in October and November skunkbush and snowberry predominated. Sixteen November rumen samples contained 8% silver sagebrush, which shows a change-over to the winter diet. Alfalfa made up 7% of the November food habits, and mushrooms made up 6%. By January, the mule deer diet appeared to consist strictly of shrubs with silver sagebrush and skunkbush predominant. In February big sagebrush and rubber rabbitbrush comprised 86% of the diet. Spring foot habits were more evenly divided: shrubs dropped to 41%, forbs rose to 24%, and grass comprised 39%.

Numbers of mule deer harvested in the Colstrip area can be seen in Table 10-46. The number of hunters has been rising. Harvest of deer has varied with hunter success, weather, and

Table 10-44

Seasonal Habitat Use of Mule Deer
in the Colstrip Study Area.

Habitat Type	Oct-Dec (130)[1]	Jan-Mar (991)	Apr-May (514)
Ponderosa Pine Forest	28 [2]	44	19
Ponderosa Pine Openings [3]	4	27	7
Big Sagebrush-Grassland	23	17	40
Grassland	5	2	3
Creek Bottom	5	6	10
Agricultural	36	4	22
Total	101	100	101

[1] Number of Observations
[2] Percent of Total Observations
[3] These are similar in vegetative composition to the Big Sagebrush-Grassland Type.

TABLE 10-45 Yearly Food Habits of Mule Deer within the Colstrip Study Area Expressed as Percentage of Instances of Use or as Percentage of Rumen Content.

	June- 11 Sites[1] (768)[2] (Knapp 1972)	July- 11 Sites (972) (Knapp 1972)	Aug.- 13 Sites (1,515) (Knapp 1972)	Sept.- 3 Sites (152) (Knapp 1972)	Oct.- 31 Rumens[3] (Field Data 1973)	Nov.- 17 Rumens (Field Data 1973)	Jan. - 2 Sites (131) (Knapp 1972)	Feb. - 4 Sites (2,084) (Knapp 1972)	March-May-6 Rumens (Eustance 1971)
SHRUBS									
Boxelder									7
Silver sagebrush	Tr[4]				1	8	35	2	8
Big sagebrush								38	7
Rubber rabbitbrush					2	2		48	1
Horizontal Juniper									2
Rocky Mountain Juniper						3	4	2	
Ponderosa pine					Tr		12		Tr
Chokecherry			7						1
Prairie rose	12	1	11		1				5
Skunkbrush sumac	27	47	49	64	36	21	50	12	
Snowberry					23	13			8
Unidentified shrubs					4	5			2
Total Shrubs	39	48	67	64	67	52	101	102	41
FORBS									
Fringed sage				2					
Aromatic aster					2				
Western aster			2						
Aster			1		1	2			

TABLE 10-45 (Continued)

FORBS (Continued)	June-11 Sites[1](768)[2] (Knapp 1972)	July-11 Sites (972) (Knapp 1972)	Aug.-13 Sites(1,515) (Knapp 1972)	Sept.-3 Sites(152) (Knapp 1972)	Oct.-31 Rumens[3] (Field Data 1973)	Nov.-17 Rumens (Field Data 1973)	Jan.-2 Sites(131) (Knapp 1972)	Feb.-4 Sites(2,084) (Knapp 1972)	March-May-6 Rumens (Eustance 1971)
Milkvetch	3	9	1						
Wavyleaf thistle					1	2			
Narrow-leaved collomia	1								
Unidentified Composites					1	2			
Prairie smoke									1
Lactuca serriola	2	21	1						
Alfalfa	4	9	23		8	7			
Mushroom					3	6			
Phlox									2
Woolly groundsel			6						
Unidentified Ranunculaceae									6
Dandelion				33					
Salsify	45	11	Tr			2			13
Soapweed	4				1	1		Tr	
Unidentified Forbs	1				10	17			2
Total Forbs	60	50	34	35	27	39	-	Tr	24
Unidentified grasses	-	-	1	-	3	5	-	-	39
TOTAL	99	98	102	99	97	96	101	102	104

[1] Number of sites observed
[2] Instances of use (bites)
[3] Number of rumens analyzed
[4] Tr = Trace

Table 10-46

Mule Deer Harvest Data for Hunting Districts 721, 722 and Region 7, 1969 to 1973

	District 721 1/	District 722 2/	Region 7 3/
1973			
Total Mule Deer Harvested	555	657	27,855
Mule Deer Harvest per sq. mi.	0.54	0.48	1.1
Total Hunters	1,322	1,309	45,735
1972			
Total Mule Deer Harvested	668	946	24,078
Mule Deer Harvest per sq. mi.	0.65	0.70	0.94
Total Hunters	1,212	1,781	37,685
1971			
Total Mule Deer Harvested	621	1,134	20,698
Mule Deer Harvest per sq. mi.	0.61	0.84	0.81
Total Hunters	983	1,720	30,807
1970			
Total Mule Deer Harvested	411	858	15,795
Mule Deer Harvest per sq. mi.	0.40	0.63	0.62
Total Hunters	430	928	19,102
1969			
Total Mule Deer Harvested	288	643	15,499
Mule Deer Harvest per sq. mi.	0.28	0.47	0.70
Total Hunters	339	676	19,739

1/ Hunting District 721 is bounded by Rosebud Creek, the Tongue and Yellowstone Rivers, and the Northern Cheyenne Indian Reservation.

2/ District 722 is bounded by Rosebud and Sarpy Creeks, the Yellowstone River, and the Northern Cheyenne Indian Reservation.

3/ Region 7 includes Treasure, Rosebud, Garfield, Prairie, Custer, Powder River, Dawson, Wibaux, Fallon, and Carter Counties.

available places to hunt but regionwide has also been increasing. One-third (27,855) of all mule deer harvested in the state in 1973 came from southeastern Montana. This amounts to slightly over one deer harvested for every square mile.

2. White-tailed Deer

Since the 1940's, white-tailed deer have gradually extended their range over most of the state of Montana. East of the continental divide, whitetails have become common along bottomlands and most major rivers and streams. They are usually associated with deciduous vegetation along drainages, often close to agricltural areas. Vegetation on these bottoms generally includes a combination of green ash, boxelder, cottonwood, willow, and associated shrubs, forbs and grasses.

One hundred and fifty-three observations of whitetails were made in the Colstrip study area. The Yellowstone, Tongue, and Bighorn River bottoms support major populations. Rosebud Creek has a substantial population, and smaller populations may exist along Armells and Sarpy Creeks.

Whitetail productivity is rated as excellent in southeastern Montana, and it has been improving steadily for the last several years. The fawn-to-adult ratio has increased from 55 fawns per 100 adults in 1969 to 122 fawns per 100 adults in 1973 (Eustace 1974).

Stomach samples from white-tailed deer collected from the Missouri River bottomlands showed that browse was the major forage during all seasons except summer, when forbs were most important. Preferred browse plants include chokecherry, serviceberry, skunkbush sumac, snowberry and red dogwood. Other browse plants include wild rose, green rabbitbrush, greasewood, buffalo berry, and various species of sagebrush. Western snowberry was the predominant plant in the yearlong diet, while alfalfa and grain are important when available (Allen 1971).

In the Colstrip area (Hunting Districts 721 and 722), whitetails have accounted for approximately 5% of the total deer harvest, while in Region 7 they account for almost 20% (Table 10-47). While the number of whitetails harvested has been increasing, the proportion they represent in the total harvest has not increased.

3. Antelope

A total of 1059 observations of antelope was recorded within the Colstrip study area. Distribution is shown on the Wildlife-Mammals General Distribution Map, but it should be understood that this map shows only a generalized distribution over a large area. Therefore, some of the small, isolated antelope populations are not denoted. Also, there are seasonal changes in antelope distribution; winter ranges are shown on the Mammals-Critical Areas Map. Of 116 antelope

Table 10-47

White-tailed Deer Harvest in Hunting Districts 721 and 722 and Region 7, 1969 to 1973

	District 721[1]	District 722[2]	Region 7[3]
1973			
White-tail harvest	85	16	6,925
Percent of total deer harvested	12	2	19
1972			
White-tail harvest	43	46	4,688
Percent of total deer harvested	6	5	16
1971			
White-tail harvest	31	56	4,255
Percent of total deer harvested	5	5	17
1970			
White-tail harvest	22	81	3,164
Percent of total deer harvested	5	9	16
1969			
White-tail harvest	10	18	4,214
Percent of total deer harvested	3	3	21

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[1] Hunting District 721 is bounded by Rosebud Creek, the Tongue and Yellowstone Rivers, and the Northern Cheyenne Indian Reservation.

[2] District 722 is bounded by Rosebud and Sarpy Creeks, the Yellowstone River, and the Northern Cheyenne Indian Reservation.

[3] Region 7 includes Treasure, Rosebud, Garfield, Prairie, Custer, Powder River, Dawson, Wibaux, Fallon and Carter Counties.

observations during fall, 53% were in the open big sagebrush-grassland vegetation type, 38% were in ponderosa pine openings, and the remaining 9% were on agricultural lands (Table 10-48).

During winter, the percentage of antelope observed on the big sagebrush-grassland type dropped to 47%, probably due to a more extensive inventory. Animals were seen on types not investigated during fall, such as open grassland, which accounted for 25% of the winter observations. Bayless (1969) found that 71% of his winter observations were in the big sagebrush-grassland type. He also noted some movement of antelope from grassland to sagebrush types during periods when snow covered the ground.

During spring, 67% of the antelope observations were in the big sagebrush-grassland type or openings within the ponderosa pine forest, but there was a general dispersal into various other types, such as ponderosa pine forest and agricultural land. Antelope were not studied during summer. However, Bayless (1969) found the big sagebrush-grassland type to receive more use than any other during summer and that use steadily decreased toward fall. The grassland and cropland type received greater use during early fall. This change is probably related to earlier desiccation of forbs on the big sagebrush-grassland type than on other types. Other studies, including Wentland (1968), Roberts (1970), Campbell (1970) and Freeman (1971), all noticed the same trend.

Aerial antelope surveys were made in Hunting Districts 721 and 722 in 1963, 1966, 1969, 1972 and 1974 (Table 10-49). The fawn/doe ratios compare favorably with ratios from Campbell (1970), and Roberts (1970). Antelope fawn/doe ratios can vary significantly from year to year due to summer and winter range conditions. Densities in this area are not nearly as high as in hunting districts farther east, because the extent of the big sagebrush-grassland type is much more limited.

Forbs are the most important forage class during summer, constituting nearly all of the total use in June (Table 10-50). The most important of these forbs are fringed sagewort, longleaf sagebrush, three-leaved milkvetch, alfalfa and yellow sweetclover (Wentland 1968). Shrubs that were utilized included big sagebrush, rubber rabbitbrush and rose.

In fall, forb use dropped considerably. Important forbs were alfalfa, three-leaved milkvetch, fringed sagewort and Nuttal goldenweed. October samples showed an unusually heavy use of snowberry. The single most important shrub was silver sagebrush. These fall food habits data were obtained from hunter-harvested antelope killed in close proximity to Colstrip in 1973.

During winter, the antelope's diet is composed almost entirely of shrubs. The species consumed consist almost entirely of big sagebrush and silver sagebrush. The remainder of the diet

Table 10-48

Seasonal Antelope Use of Vegetation Types in the Colstrip Study Area

Major Type	Sept-Dec (116)[1]	Jan-Mar (677)[1]	Apr-May (266)[1]
Big Sagebrush-Grassland	53[2]	47	55
Ponderosa Pine Forest	-	-	5
Ponderosa Pine Openings [3]	38	26	12
Agricultural	9	2	13
Grassland	-	25	15
	100	100	100

[1] Number of observations

[2] Percent of observations

[3] Including big sagebrush and grassland

TABLE 10-49

Aerial Antelope Survey Data for Hunting Districts 721 and 722.

Hunting District	Square Miles	Year	Bucks	Does	Fawns	Total[1]	Density	Fawns/ 100 Does	Males/ 100 Females	Fawns/ 100 Adults
721	1,024	1963	130	257	261	667	0.7	102	51	66
		1966	30	99	72	201	0.2	73	30	56
		1969	112	252	231	607	0.6	92	44	63
		1972	94	321	231	646	0.6	72	29	56
		1974	131	329	178	638	0.6	54	40	39
722	1,355	1963	54	143	148	350	0.3	103	38	75
		1966	55	198	169	424	0.3	85	28	67
		1969	74	228	197	503	0.4	86	32	65
		1972	78	324	209	611	0.5	65	24	52
		1974	50	170	53	273	0.2	31	29	24

1 - Includes bucks, does, fawns, and unclassified adults

TABLE 10-50

Yearly Food Habits of Antelope in Southeastern Montana [1] Expressed as Percentage of Instances of use or as Percentage of Rumen Content

	June (6)^2 (582)^3	July (16)^2 (1990)^3	Aug. (12)^2 (1567)^3	Sept. (3)^4	Oct. (9)^4	Nov. (1)^4	Jan. (9)^4	Feb. (12)^4	Mar. (7)^4	Apr. (8)^2 (1144)^3	May (9)^2 (1835)^3
Shrubs											
Silver sagebrush				1	35	46	19	4	11	36	
Big sagebrush		6	8	Tr	1		76	79	78	15	12
Rubber rabbitbrush	6	12	3	1				3	5		
Broom snakeweed											1
Prairie rose		8	2	11	1						
Greasewood	Tr[5]			10							3
Western snowberry									3	2	
Snowberry					21						
Unidentified shrubs					14						
Others											1
Total Shrubs	Tr	20	22	25	73	46	95	86	97	53	16
Forbs											
Yarrow		Tr								2	19
Small-leaf pussytoes					3						Tr
Arnica fulgens											2
Fringed sage	17	1	17	8		6	Tr	11	3		
Longleaf sagebrush		3	28	1							
Aster				3			2				6
Threeleaved milkvetch	29	12		6							
Pale bastard toadflax				1							18
Erigeron pumilus	17										
Scarlet gaura		2									
Nuttall goldenweed				9							
Lomatium Foeniculaceum										26	20
Lomatium macrocarpum										13	5

TABLE 10- 50 Continued.

Forbs (Continued)	June (6)[2] (582)[3]	July (16)[2] (1990)[3]	Aug. (12)[2] (1567)[3]	Sept. (3)[4]	Oct. (9)[4]	Nov. (1)[4]	Jan. (9)[4]	Feb. (12)[4]	Mar. (7)[4]	Apr. (8)[2] (1144)[3]	May (9)[2] (1835)[3]
Alfalfa		12	3	45							
White sweetclover		1	4								
Yellow sweetclover	33	35	18								1
Nuttall monolepis											2
Plains pricklypear		4			4						
Purple prairie-clover	4										Tr
Prostrate knotweed		5									
Silverleaf scurfpea											2
Salsify		1	8	1							
American vetch		1								Tr	2
Unidentified Forbs		1			9	48				2	Tr
Other Forbs (15)	1	1	1	1	4						1
Total Forbs	101	79	78	73	20	54	3	11	3	43	78
Unidentified grasses	Tr			Tr	7		Tr	2		2	1
TOTAL	101	99	100	198	100	100	100	99	100	98	95

[1] June through September from Wentland (1968); October and November from field data (1973); January through March from Bayless (1969); April and May from Campbell (1970).

[2] Number of separate feeding sites

[3] Instance of use (bites)

[4] Number of rumens sampled

[5] Tr = trace

was mostly fringed sagewort. The high use of these three plants, all species of sagebrush, illustrates the importance of sagebrush to antelope.

In early spring, big sagebrush and silver sagebrush were still the main items in the diet, but a trend toward more forb use became evident. Two species of lomatium made up 39% of the April diet. By May, forbs constituted 78% of the diet, with lomatium, yarrow, and toadflax comprising the bulk. Although the antelope's yearlong diet consists mainly of about 17 species of plants in large quantities, many other species are consumed in smaller amounts. This variety of species may be necessary for a balanced diet.

Harvest data for Hunting Districts 721 and 722 and Region 7 are shown in Table 10-51. Harvest of antelope may vary considerably in any one hunting district, fluctuating with the antelope population, number of permits granted, and hunter success. In Region 7, hunter demand and harvest have been steadily rising. In 1968 about 4,000 antelope were harvested, whereas in 1972 over 9,000 were taken. Harvest dropped in 1973, mainly because the Department of Fish and Game reduced the number of permits in accordance with field observations of antelope populations.

4. Bighorn Sheep

There is a small bighorn sheep population east of Miles City, the result of a transplant of 11 sheep into the area in 1958. The only information available about this herd is that a huntable population, estimated at 75 to 100 sheep, does exist, and permits for two animals are issued each year. In the period from 1969 to 1973, a total of 10 permits was issued and 5 rams were killed, for a hunter success of 50%.

B. Furbearers and/or Predators

The major furbearers/predators in the study area are beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), raccoon (*Procyon lotor*), fox (*Vulpes vulpes*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), long-tailed weasel (*Mustela frenata*), skunk (*Mephitis mephitis*), and badger (*Taxidea taxus*).

Beavers and muskrats are vegetarians and are associated with waterways. Mink are found near water but are not restricted to it. Raccoons are found throughout the study area in association with major waterways, and foxes are generally associated with brushy areas along drainages. Coyotes and bobcats are found throughout the study area, as are skunks, badgers and weasels.

C. Small Mammals

Small mammals found throughout the study area include whitetail jack rabbit (*Lepus townsendi*), cottontail (*Sylvalagus* spp.), thirteen-lined ground squirrel (*Citellus tridecemlineatus*), blacktail prairie dog (*Cynomys ludovicianus*), and porcupine (*Erethizon dorsatum*). Yellowbelly marmot (*Marmota flaviventris*) and red

TABLE 10-51

Antelope Harvest Data for Hunting Districts 721 and 722 and Region 7, 1969 to 1973

	District 721	District 722	Region 7
1973			
Air count	-	-	-
Permits issued	300	200	12,713
Harvest	192	94	8,074
Percent Success	79	65	73
Hunters	242	144	11,079
1972			
Air count	646	611	---
Permits issued	409	260	15,051
Harvest	243	132	9,247
Percent Success	73	59	7 72
Hunters	332	223	12,820
1971			
Air count	-	-	---
Permits issued	201	197	13,131
Harvest	116	112	8,176
Percent Success	70	69	72
Hunters	164	164	11,312
1970			
Air count	-	-	---
Permits issued	200	200	10,127
Harvest	160	138	7,106
Percent Success	84	72	80
Hunters	189	192	8,924
1969			
Air count	607	503	
Permit issued	194	198	9,935
Harvest	103	110	6,303
Percent Success	67	68	75
Hunters	153	161	8,402

squirrel (Tamiasciurus hudonicus) are found in localized areas. Additionally, a large variety of smaller rodents is located in varied habitat types throughout the area. Locations of prairie dog towns are indicated on the Wildlife-Mammals maps.

10.1.7.2. Birds

A. Upland Game Birds

Major upland game birds located in the study area include Merriam's turkey (Meleagris gallapavo merriami), sage grouse (Centrocercus urophasianus), sharp-tailed grouse (Pediocetes phasianellus), pheasants (Phasianus colchicus), and gray partridge (Perdix perdix).

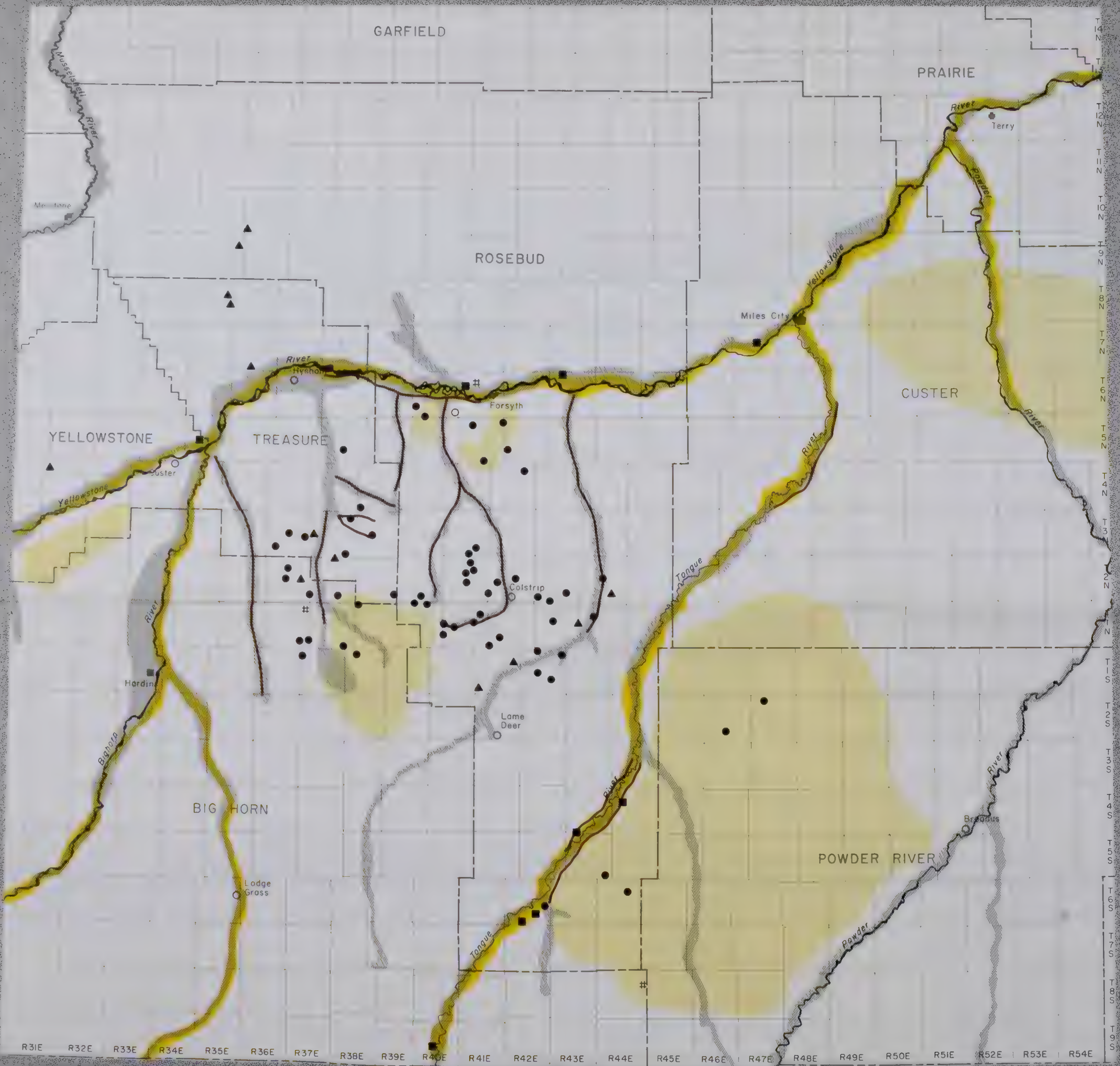
1. Turkeys

Turkeys are one of the more exotic, if not numerous, game birds found within the Colstrip study area. The major concentrations are east of Miles City, south of Forsyth, Sarpy Basin, and the Custer National Forest between the Tongue and Powder Rivers (see Wildlife-Birds Map). Turkeys have been most successful in forests such as those found in the Longpines Division of Custer National Forest, where about one-half of the vegetative cover consists of ponderosa pine with the remainder a mixture of grasses, deciduous trees, and brush in scattered small openings and drainage-ways throughout. Mature ponderosa pine trees are preferred for roosting, and denser stands of smaller trees are used for resting and escape cover. Stands of pole-size pine with an open understory and good ground cover are used by turkeys during all seasons of the year, while use of other plant communities is more seasonal (Greene and Ellis 1971).

In summer, grassland receives greater usage than any other type, mainly because of increased late season usage which is possibly related to a change in turkey food habits from grasshoppers to grass seeds. Little use was made of grasslands in winter, but there is a shift back to grassland in spring. During winter, turkeys move into the lower drainages consisting of deciduous trees and brush.

A mixture of different types of vegetation and the resulting edge effects are essential elements of turkey habitat (Greene and Ellis 1971). In the Longpines Division, most of the turkeys observed in grasslands were within 100 yards of trees and shrub cover (Jonas 1966). In snowberry brush, turkeys were associated with brush-grass edges near the forest where many poults (young birds) fed and found concealment during summer. Turkeys used the nearest cover when disturbed; however, when there was a choice in the pine community, the preference order, from first to last, was pole, sawlog and sapling stands. Nesting activities are associated with the edge of deciduous trees and brush.

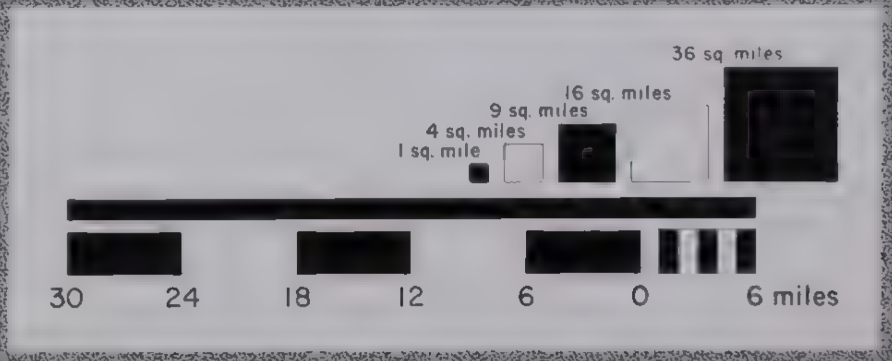
Seeds, fruits and berries are the main items



WILDLIFE
BIRDS

- ▨ Ring Necked Pheasant – general distribution
- — Pheasant crow count route
- 🟨 Merriam's Turkey – general distribution
- 🟨 Waterfowl – breeding areas
- ▲ Sage Grouse – strutting ground
- ● Sharptail Grouse – dancing ground
- ■ Heron Rookery
- # Golden Eagle Nest
- ○ Prairie Falcon Nest

SOURCE: F&G, USFS, BLM



in the turkeys' diet, but importance of individual items varies each year. Ponderosa pine seed, snowberry seed, domestic grain and kinnikinnick are the most abundant items in the crop samples. Grasshoppers are the only significant animal group. During winter and spring green grass blades are very important. Poults feed almost exclusively upon insects in early summer (Jonas 1966).

The Merriam's turkey has a high reproductive potential, averaging approximately 7 young per brood (Wallestad 1974). Jonas (1966) noted that about 50% of a turkey population disappears each year whether hunted or not. In 1973, 21 turkeys were harvested from Rosebud County. Powder River and Carter Counties had the highest harvests in the area surveyed with 101 and 143 birds, respectively (Table 10-52).

2. Sage Grouse

Within the Colstrip study area, sage grouse are abundant only within the rolling sagebrush-grassland plains of Powder River, Custer and Rosebud Counties north of the Yellowstone River. The sagebrush canopy coverage at sites used by adults for all seasons averages about 25% (Martin and Pyrah 1971). A similar sagebrush coverage was obtained at sites used by early broods in central Montana (Peterson 1970). Although sage grouse are not considered migratory, they may move considerable distances in fall to areas of dense and abundant sagebrush which they use almost exclusively for food and cover. This association apparently begins in late August or early September (Wallestad 1971) and continues at least until the peak of breeding in early April. Breeding males continue to use dense stands of sagebrush until early May (Schladweiler 1969). Thus, dense stands of sagebrush may be selectively used by sage grouse for seven to eight months of the year (Eng and Schladweiler 1972).

During summer the sage grouse diet is comprised mainly of dandelion, salsify, wild lettuce, fringed sagewort, curlcup gumweed, and grasshoppers. Various species of sagebrush (fringed sagewort, silver sage, and big sagebrush) supply the major portion of the food during other seasons. Big sagebrush accounts for nearly 100% of the winter diet (Martin and Pyrah, 1971).

Six sage grouse strutting grounds are located within the Colstrip study area and shown on the Wildlife-Birds Map. On five of these grounds, the number of male birds observed ranged from 3 to 16, with an average of 13 males per ground. Brood sizes in southeastern Montana have averaged five young from 1963 to 1973. According to Wallestad (1974), a definite population trend has been evident over the past 11 years in southeastern Montana. The sage grouse population was at a high in 1963, dropped in 1964 (production of 46 juveniles/100 adults), and remained fairly low through 1967. In 1968, the population began increasing (production of 241 juveniles/100

Table 10-52

Turkey Harvest by County in Southeastern Montana as Determined from Mail Questionnaire Surveys from 1971 to 1973 and for the Period from 1968 to 1973

		COUNTIES						
		Carter	Custer	Garfield	Pwdr. R.	Rosebud	Others 1/	Total
1971	No. Hunters	122	75	86	257	66	2	608
	Percent Success	49	26	44	57	41	0	47
	Birds Harvested	59	20	38	147	27	0	291
1972	No. Hunters	204	89	115	344	72	13	837
	Percent Success	51	29	55	39	17	54	41
	Birds Harvested	105	26	63	134	12	7	347
1973	No. Hunters	321	156	215	360	80	38	1170
	Percent Success	45	32	18	32	26	29	33
	Birds Harvested	143	51	38	101	21	8	362
Totals 1968 to 1973	No. Hunters	1117	573	901	1622	336	79	4628
	Percent Success	39	35	30	38	27	23	36
	Birds Harvested	431	198	272	620	91	18	1630

1/ Treasure, Prairie, Dawson, Wibaux, and Fallon Counties adults) and continued at a fairly high level through 1973. If sage grouse populations are on a 10-year cycle, as reported for other gallinaceous birds in North America, a marked population decrease should occur within the next few years. In 1973, the juvenile/adult ratio was 170/100.

In 1973, sage grouse accounted for 16% of the upland game bird harvest in southeastern Montana, or 7,636 birds. Rosebud County ranked second among the counties of southeastern Montana with a harvest of 1,219 birds.

3. Sharp-tailed Grouse

Sharp-tailed grouse, found throughout the Colstrip area, are the most abundant game birds in southeastern Montana. The Great Plains sharptail remains seasonally abundant in the more moist upland areas where mixed-prairie rangelands have been maintained in reasonably good condition (Brown 1971b). There are two important elements of the native prairie necessary for sharptail existence. The first is standing grasses, left over from fall to spring, which are required for shelter, protection from predators, night roosting, and spring nesting activities. Dense cover, consisting of trees and shrubs, is the other essential, necessary for food, rest, escape cover, and winter survival (Brown 1971b). Southeastern Montana and the Colstrip study area provide these requirements in abundance.

During periods of high populations, breeding sharptails extend their range well into the marginal islands of native grasslands, usually along drainages surrounded by wheat, barley, or summer fallow. Conversely, during low populations sharptails are more restricted to the upper limits of drainages with the best stands of intermixed tree-shrub-grasslands. The majority of 477 observations of sharptails in the Colstrip area were in the big sagebrush-grassland type, grassland plateau type, and grassland and big sagebrush-grassland openings within the ponderosa pine type.

Last spring Montana Department of Fish and Game personnel found 58 sharptail breeding grounds in the Colstrip study area (see Wildlife-Birds Map). On 51 of these grounds, 597 male sharptails were observed. The number of males per ground ranged from 3 to 21, the average being 12. Only males are counted because they stay on the grounds and display for several hours in early morning, whereas females are constantly coming and going and appear in peak numbers only at the height of breeding. According to Brown (1967), hens often nest within 0.5 mile of the breeding ground and have brood ranges of 0.6 to 1.25 miles from the ground for up to eight weeks of brood development. It is evident that the breeding ground and a 1 to 1.5 mile radius from it are critical to sharptail production. Brood size for southeastern Montana averages 6.7 young. Age ratios for the last 14 years, as determined from hunter-killed birds, averaged 2.4 juveniles per adult.

Food habits of sharptails are varied. In a study conducted in Canada (Pepper 1972), approximately 27 different species of plants and animals were consumed. The most important species eaten were wheat, dandelion leaves, barley, oats, black bindweed seeds, wood's rose, western snowberry, grass leaves, and fringed sagewort leaves.

From a study in South Dakota, cultivated crops were first in importance during summer, fall and winter (Hillman and Jackson 1973), while common dandelion ranked first during spring. Grasshoppers were the most important insect during summer, fall and winter. Preference indices for food items taken by 48 adult sharptails during summer indicated selectivity for rose hips, snowberry, and prickly lettuce.

Crops taken from sharptails killed in southeastern Montana contained 40 different food items, including as major items wheat seeds, common salsify heads, dandelion, rose, skunkbush, wild lettuce, and silverberry. The plant parts usually eaten are flower heads, seeds, and pieces of leaves. Their diet is varied, and they consume seeds of many so-called useless weeds.

In 1973, an estimated 29,113 sharptails were harvested in southeastern Montana. This is 61% of all game birds harvested in the area. Rosebud County contributed 5% of the sharptail harvest or about 1,456 birds, which was exceeded only in Dawson and Custer Counties.

4. Ring-necked Pheasant

Pheasants are present along most of the drainage bottoms throughout the study area. Prime pheasant habitat consists of cultivated lands, along with an abundance of weeds, shrubs, and trees for cover. Of the 342 observations of pheasants made within the Colstrip study area, 88% were in agricultural and creek bottom vegetation types, and the remainder along roadsides.

Pheasant populations in southeastern Montana were high in the early 1960's, but declined drastically following the severe winter of 1964-1965. Since that time, pheasant populations appear to have slowly increased and are again approaching the levels of the early 1960's (Wallestad 1974).

Twelve pheasant crow-count routes, shown on the Wildlife-Birds Map, were established in the study area in order to establish an index for following population trends (Table 10-53). In this method, the total number of pheasant "crows" heard during a two-minute period are recorded for each stopping point (at one-mile intervals) along the route. The resulting figure provides an index to the male pheasant population which can be used for yearly comparisons of population levels. For the purpose of this report, an average number of calls ranging between 10 and 20 per two-minute stop is considered indicative of a fair to good pheasant population, and any average number of

TABLE 10-53
Pheasant Crow-count Data for 12 Routes in the Colstrip Study Area.

	1974	1973	1972	1971	1970
Tongue River (Birney-Ashland)	6.7[1]				
Tongue River (Pumpkin Creek access up river 25 miles)	9.7				
Rosebud Creek	14.6	17.7	18.1	16.8	19.6
Armells Creek	4.1				
West Fork Armells	0.4				
Reservation Creek	4.3				
Tulloch Creek	7.6				
Sarpy Creek	7.9	27.2	29.0	34.3	26.0
East Fork Sarpy Creek	4.0				
Beaver Creek	3.0				
Otter Creek	37.0	-	19.9	11.0	-
Yellowstone River (Forsyth)	3.9				

[1] Average number of calls per two-minute stop.

calls exceeding 20 per two-minute stop is considered indicative of a good population. This method shows Otter Creek to have good pheasant populations. Rosebud Creek falls into the fair-to-good category, but the other areas apparently have smaller pheasant populations.

Food habits of pheasants in Montana are varied. Hiatt (1947) found 13 plant species in their year-round diet. Cultivated grains made up the major portion of their diets, followed by cutworms, grasshoppers, snowberry seeds, beans, and field crickets. Hiatt's food habits study was conducted in the highly agricultural portion of the Bighorn valley. Pheasant populations in regions of less intensive agriculture, such as the Colstrip area, probably depend more on naturally occurring food supplies.

Pheasants accounted for 18% of the 1973 game bird harvest in southeastern Montana, which amounted to 8,600 birds. The estimated pheasant harvest in Rosebud County was 1,546 birds, the third highest harvest among southeastern Montana counties.

5. Gray Partridge

Gray partridge are found throughout southeastern Montana, but not in abundance. Optimum conditions for a flourishing population are a cool, moderately dry climate and a mixture of cultivated and noncultivated land. Partridge populations have responded favorably to the increase in grain growing since 1940, with waste grain providing one of their staple fall and winter foods.

Although the gray partridge seems to survive under certain intensified agricultural land uses, some farming and ranching practices tend to limit their distribution. The trend toward farm consolidation has resulted in destruction of field edges which provide escape and winter cover. The transformation of grain fields into pasture and alfalfa fields also reduces the amount of ideal partridge habitat. More recently, the fall plowing of winter wheat stubble had destroyed vast acreages of winter habitat (Trueblood and Weigand 1971).

Coveys are usually interspersed through sharp-tailed grouse and pheasant habitat. During winter, partridge are found in coveys of 15 or more birds. By early March, most coveys have broken up, and breeding pairs have formed. Egg laying begins in late May or early June, and clutches of 12 to 18 eggs are common. Brood sizes decrease by one-third or more by September. The annual turnover in a partridge population is approximately 75% (Trueblood and Weigand 1971).

Over the last five years the juvenile/adult ratio, as determined from hunter harvested birds, has been three juveniles per adult. In 1973, gray partridge made up 4% (1,909 birds) of the total bird harvest for southeastern Montana. Dawson County had the highest gray partridge harvest

(889), and Rosebud County was second with 178 birds.

B. Waterfowl

1. Canada Geese

Counts of breeding pairs of Canada geese (Branta canadensis) along the Yellowstone River and its major tributaries during 1967 and 1974 indicate a build-up of breeding populations (Table 10-40), which is probably due to the pioneering of nest sites on many islands not previously used for nesting (Hinz 1974). The large discrepancy between the 1967 and 1974 breeding pair counts along the Bighorn, Tongue and Powder Rivers (Table 10-54) is probably partially due to a true increase in the breeding populations, although the 1967 counts were not as intensive.

Geese along the Yellowstone River prefer to nest on islands (Hinz 1974). This preference has also been reported by numerous other workers studying Canada geese on North American rivers (Dimmick 1968, Geis 1956, and Hanson and Eberhardt 1971). Based on an estimated 70% nesting success (Geis 1956) and 4.5 young fledged per successful nest (Craighead and Craighead 1949), production for the Yellowstone River each year may be about 2,300 young. These young are brooded in the early summer in backwaters of the river, riverside meadows, and hayfields.

In addition to an estimated breeding population of over 800 pairs within the river system (Table 10-54), the Yellowstone River has also become a stopover for large numbers of spring migrants. An aerial census from Sidney to the Bighorn River on March 11, 1974, revealed a total of nearly 9,600 geese.

By late summer, exposed gravel islands and bars, sandbars, and silt banks of the river serve as resting sites for resident geese and also for nonbreeders, which are believed to return to the Yellowstone by this time. The security afforded by the river and associated islands, as well as the attractiveness of nearby grainfields for field feeding, also draw large numbers of geese migrating through the Yellowstone valley in the fall (Hinz 1974).

Goose numbers along the Yellowstone River and its larger tributaries grow through the fall. The largest increase usually follows a cold weather system moving down from the north, which normally occurs between the end of October and mid-November. The number of geese stopping in the lower Yellowstone Valley in recent years appears to be increasing, although the dates of earlier fall counts probably did not coincide with periods when peak goose numbers were present (Table 10-55). The higher use of the Yellowstone and its tributaries by geese in the fall is believed to be related to an increase in acreage of irrigated grain along the rivers, coupled with a possible increase of goose numbers in the Central Flyway.

TABLE 10-54

Canada Goose Breeding Bair Surveys on the Yellowstone River and Major Tributaries, 1967 and 1974.

Section	Pairs 1967	Pairs 1974	Lone Birds 1967	Lone Birds 1974	Birds in Groups 1967	Birds in Groups 1974	Total Individual Birds 1967	Total Individual Birds 1974
Yellowstone River								
Sidney to Glendive (52)[1]	1	17	2	17	0	35	4	86
Glendive to Miles City (85)	5	36	5	31	16	72	31	175
Miles City to Forsyth [2](45)	99	51	76	26	118	53	392	181
Forsyth to Bighorn[2] (44)		80		37		50		247
Bighorn to Billings[3] (63)	45	109	25	48	53	10	168	276
Billings to Columbus (43)	13	24	10	15	27	99	63	162
Columbus to Livingston (77)	18	30	22	20	3	99	61	179
Livingston to Gardiner (57)	2	5	3	6	3	9	10	25
Totals (476)	183	352	143	200	220	427	792	1331
Tributaries of the Yellowstone								
Powder River (147)	0	38	2	12	0	13	2	101
Tongue River (113)	3	49	0	23	0	27	6	148
Bighorn River (76)	14	97	17	53	5	70	50	317
Totals	17	184	19	88	5	110	58	566
Grand Total (812)	200	536[4]	162	288[4]	225	537	850	1897

[1] Numbers indicate the estimated length of the section of river in miles.

[2] These two sections summed for 1967 as separate data are not available.

[3] Figures for Bighorn to Billings are not available for 1967; these data are for Hysham to Billings so the given figures are somewhat elevated.

[4] The sum of these two figures gives an estimate of the total breeding population (Hanson and Browning 1959).

TABLE 10-55

Peak Counts of Canada Geese in the Lower Yellowstone Valley from the Mouth of the Bighorn River to the Vicinity of Glendive.

Date	Count[1]
November 3, 1959	194
November 28, 1960	380
October 3, 1961	436
October 16, 1962	538
November 24 and December 5, 1968	3,631
November 17, 1969	4,894
November 3,5 and 23, 1970	2,061
November 9, 1971	6,160
November 9, 1972	6,808
November 12, 1973	10,006

[1] Counts made by Montana Fish and Game personnel (except 1973); peak counts on all sections not obtained on same day (1968, 1970).

Interest in goose hunting along the Yellowstone River is increasing, particularly in southeastern Montana. Goose hunters in counties adjacent to the Yellowstone River harvested an estimated 450 to 1,800 geese annually from 1963 to 1971. Most of these geese were taken along the lower Yellowstone where fall populations are the highest. Between 5 and 14% of all geese harvested in Montana from 1963 to 1972 were taken in counties along the Yellowstone River (particularly in southeastern Montana), with an erratic yearly increase being evident during that period.

When the Yellowstone River freezes over most of its length, most geese leave the river for the winter. However, limited numbers remain in isolated open stretches. For example, on January 9, 1974, 65 geese were counted from Yankee Jim Canyon to Big Timber. Similar January surveys in other years have encountered geese as far downstream as below Miles City.

2. Other Water Birds

Many species of water birds, including most species of ducks occurring in Montana, are observed along the Yellowstone River during spring migration, though information is limited as to which species nest there. Known nesters include mallards (Anas platyrhynchos), blue-winged teal (Anas discors), wood ducks (Aix sponsa) and mergansers (Mergus spp.). In addition, double-crested cormorants (Phalacrocorax auritus) and eared grebes (Podiceps caspicus) are also believed to nest along the Yellowstone.

Summer use of the Yellowstone River by ducks, particularly mallards, closely parallels that by Canada geese, with heavy use of open islands and bars of the river once the molt is completed. Small field-feeding flights of resident ducks begin to assemble after corn is harvested in late summer.

By fall, many large flocks of ducks concentrate on resting areas on the Yellowstone and its largest tributaries, with ultimate numbers reaching an estimated 60,000 ducks on the lower Yellowstone alone. Field-feeding ducks which commonly frequent riverside cornfields along the lower Yellowstone have been estimated to number up to 15,000 in a single flock. Each year about 10% of Montana's duck hunters hunt in counties bordering the Yellowstone River, and a nearly proportionate percentage of the annual duck harvest occurs in these same counties. As with goose hunting, interest in duck hunting in recent years appears to be on the increase, at least in southeastern Montana.

In winter the mallard is still a common species along the Yellowstone River, and counts of common goldeneyes (Bucephala clangula), Barrow's goldeneyes (Bucephala islandica) and mergansers sometimes outnumber the mallards. Mute swans (Cygnus olor) are also found on the upper Yellowstone River near Livingston during winter.

Great blue herons (Ardea herodias) are the most common large wading birds of the Yellowstone River during warm periods of the year, particularly near their rookeries, which are typically located in streamside cottonwood trees and support as many as 20 or more nests.

Spring arrival of herons along the Yellowstone River occurs near the first of April. At present, nine rookeries are known on the stretch of river from Livingston to Miles City, although more are probably present.

On September 5, 1961, 86 herons were counted from Miles City to Forsyth. Although recent counts are not complete, they also indicate a high number of herons using the Yellowstone River until mid-fall. Herons have also been observed on the Bighorn, Tongue and Powder Rivers, although the numbers of herons using these rivers are not as large.

White pelicans (Pelecanus erythrorhynchos) are also present along the Yellowstone River, notably in spring and early summer, and occasionally in the fall. One flock of from 40 to 80 pelicans has been observed for several months each spring between Glendive and Sidney. Small flocks of between 10 and 20 pelicans have been sighted in the Armells Creek area of the Yellowstone in spring, and similar-sized flocks occasionally use the Yellowstone near the mouth of the Powder River.

C. Raptors

Raptorial birds known to breed in the Colstrip study area include the marsh hawk (Circus cyaneus), red-tailed hawk (Buteo jamaicensis), golden eagle (Aquila chrysaetos), prairie falcon (Falco mexicanus), American kestrel (Falco sparverius), ferruginous hawk (Buteo regalis), and great horned owl (Bubo virginianus). All of these nesting species, except the prairie falcon, are common throughout the study area.

Other species which are commonly observed during spring and fall migration periods, and sometimes in summer, include the rough-legged hawk (Buteo lagopus), Swainson's hawk (Buteo swainsoni), bald eagle (Haliaeetus leucocephalus), members of the Accipiter group, and short-eared owls (Asio flammeus). Several of these species may also breed within the Colstrip study area.

Bald eagles concentrate along the Yellowstone River during spring migration. The highest count on record along the Yellowstone was made on March 11, 12, 14, and 15, 1974, when 298 eagles were counted from Yankee Jim Canyon to Sidney. None of these birds are believed to breed along the lower Yellowstone River, although some may nest along the upper reaches.

Although no eagles are present on the lower Yellowstone in summer and early fall, numbers of eagles begin to build when waterfowl move into the area in large numbers. On December 6, 1973, 110 bald eagles were counted from the mouth of the Bighorn River, to Cabin Creek near Glendive, the majority of which (69) were counted from Forsyth to the mouth of the Bighorn.

Eagle distribution along the Yellowstone River in winter seems to coincide with areas of open water where waterfowl congregate. Winter censuses on record include one on January 5, 1970, when 13 bald eagles were counted from Bighorn to Miles City, and another on January 8, 1969, when 16 eagles were counted from Reedpoint to Bighorn.

D. Small Birds

Since the Colstrip study area includes virtually all habitat types common in the Northern Great Plains region, all of the small birds indigenous to this region could be expected to occur in the study area. Additionally, a large variety of migratory small birds pass through.

10.1.7.3. Endangered Wildlife

Of the endangered wildlife included in the 1973 "red book", only two taxa may regularly occur in the study area. Although peregrine falcons (Falco peregrinus) are not known to breed in the study area, they are occasionally observed and can be expected to occur throughout. The last unconfirmed sighting of black-footed ferret (Mustela nigripes) in Montana was in 1970, and the last confirmed report of a ferret in the study area was a road kill that was collected near Ingomar, Rosebud County, in 1952 (Snow 1972). It is not known whether ferrets presently occur in the Colstrip study area.

10.1.8. Fluoride Content in Wildlife

10.1.8.1. Collection

Bone tissues of large and small animals and upland game birds were collected throughout Montana. The data are presented in three divisions: 1) analysis of animals from the National Bison Range, the Sapphire Mountains, and from various localities throughout the state; 2) analysis of the bones of animals collected from the Colstrip study area, segregated by counties; and 3) analysis of bone tissue of animals collected from specific areas of Montana known to be contaminated by fluoride pollution and listed according to area of collection.

Most of the animals listed under the first division mentioned above, with the exception of those from the National Bison Range and the Sapphire Mountains, were collected by the Montana Department of Fish and Game. Antelope from the Bison Range were collected by the University of Montana Zoology Department, and animals from the Sapphire Mountains were collected from hunters at checking stations as part of the Sapphire Mountains Cooperative Elk Study. Most of the animals from the Colstrip area were also collected by the Department of Fish and Game, and all grouse were supplied by them from hunters cooperating in that Department's Upland Game Bird Survey. Animals listed under the last division above were collected by the University of Montana or in cooperation with the Department of Fish and Game (under permit from that Department), donated by hunters, or supplied by Glacier National Park.

10.1.8.2. Analysis Method

Laboratory analysis of bone fluoride content was carried out at the Environmental Studies Laboratory at the University of Montana. The whole bones of large animals (rib, femur, tarsal, carpal, or lower jaw) were cleaned of all flesh and cartilage by boiling in 5% solution of alconox and drying at 32°C under forced draft. When clean and dry, samples were removed from the bones for analysis. In the case of femurs, tarsals, and carpals, a strip about three mm wide was removed from the longitudinal axis of each bone; a proximal, distal and medial portion of about 1" long each was removed from the ribs; and the coronoid process was removed from each lower jaw.

Samples were broken up into 1/2" lengths and boiled in 5% alconox solution to remove all remaining flesh and marrow, dried at 32°C, and boiled in six changes of 30°-60°C petroleum ether and dried again at 32°C. When dry, the samples were ground in a Wiley mill to pass a 20 mesh screen.

One-tenth and/or 0.05 gms of dried, ground bone were weighed into a nickel crucible, covered, and ashed overnight at 600°C. When cool, the ash was dissolved in a minimum of 50% concentration HCl, made to 100 ml with 50% TISAB, and the resultant solution was transferred to a 150 ml plastic beaker. Fluoride concentration was determined in the same manner as that for plant material (see Section 10.1.6.6.).

In the case of small animals such as mice and voles, both femurs were removed whole, boiled clean in a 50% solution of alconox, and dried at 32°C. When dry, the femurs were boiled in six changes of 30°-60°C petroleum ether and dried again at 32°C. When dry, the femurs were weighed into an inconel crucible, covered, and ashed over night at 600°C. The crucibles were cooled; the ash was moistened with distilled water, dissolved in a minimum of 19% HCl, and made to 100 ml with 50% TISAB; and the resultant solution was transferred to a 150 ml beaker. Fluoride concentration was determined in the same manner as that for plant material.

The carpometecarpal of the grouse wings which were received from the Montana Department of Fish and Game were utilized for fluoride analysis. These were treated in the same manner as the bones from larger animals, except that the entire bone rather than a subsample was analyzed.

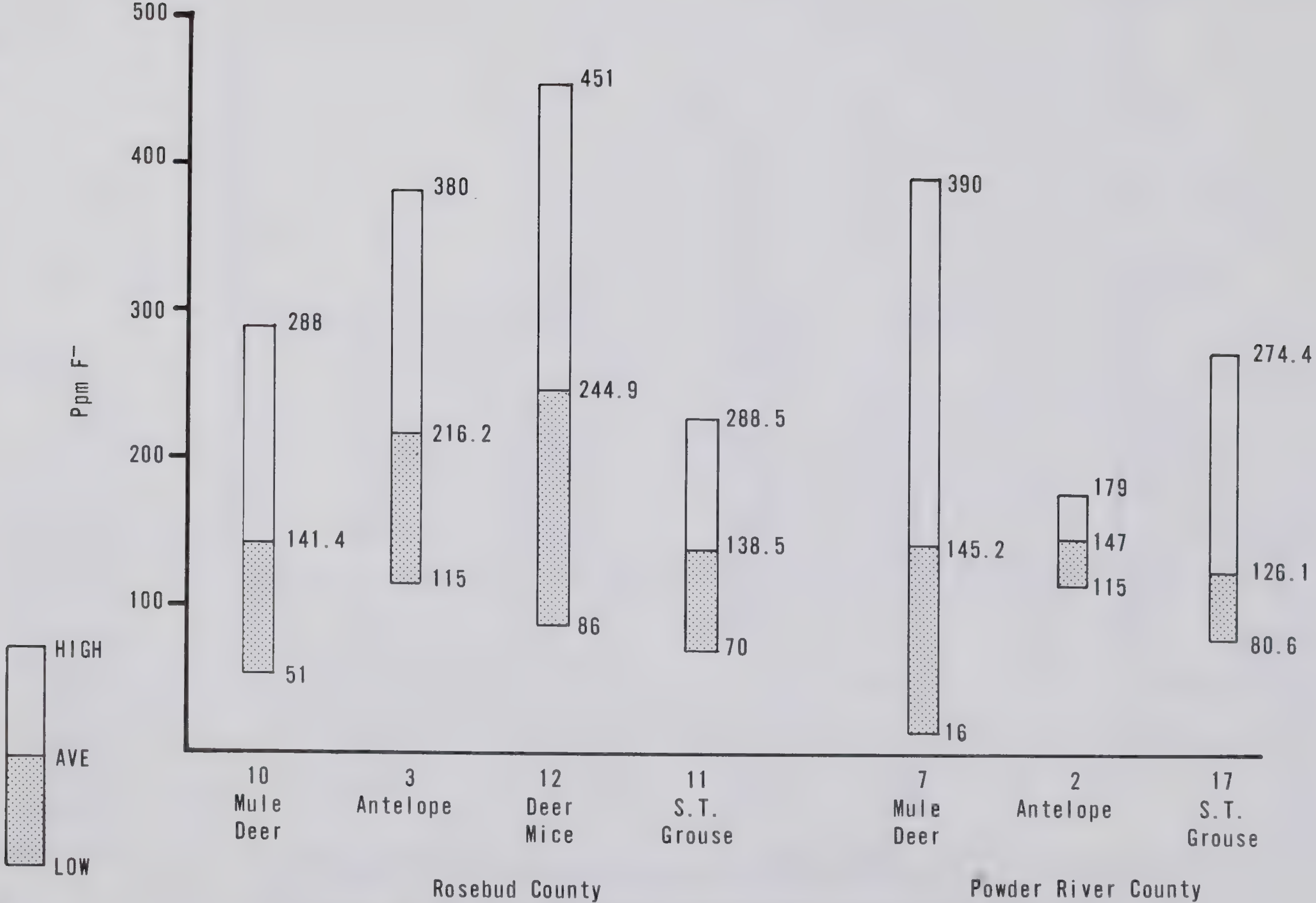
10.1.8.3. Results

Figures 10-31 and 10-32 show the high, low, and average fluoride concentrations of mule deer, antelope, grouse and deer mice collected from the Colstrip study area. The high, low and average fluoride content in grasses and shrubs collected from the same counties at vegetation sampling sites are shown in Figures 10-33 and 10-34. Figures 10-35 and 10-36 depict high, low and average fluoride content for animals collected from the National Bison Range and from areas of known fluoride contamination, respectively. The high, low and average fluoride concentrations in grass from the National Bison Range, Billings, and Glacier National Park are shown in Figure 10-37. Figure 10-38 shows the high, low and average fluoride concentrations in grass from other fluoride contaminated areas in Montana where animals were also collected.

An inspection of Figures 10-31 and 10-32 shows that, at least for the same species, the fluoride contents are within the same range as those from the National Bison Range (Fig. 10-35). An examination of the data collected under the first division mentioned above for the same species reveals essentially the same comparison, except the Sapphire Mountain collection, which shows a lower level of fluoride concentration, and except for an 11 year-old mule deer from Lake County and a 15 year-old mule deer from Yellowstone National Park, which show 769 and 585 ppm fluoride, respectively.

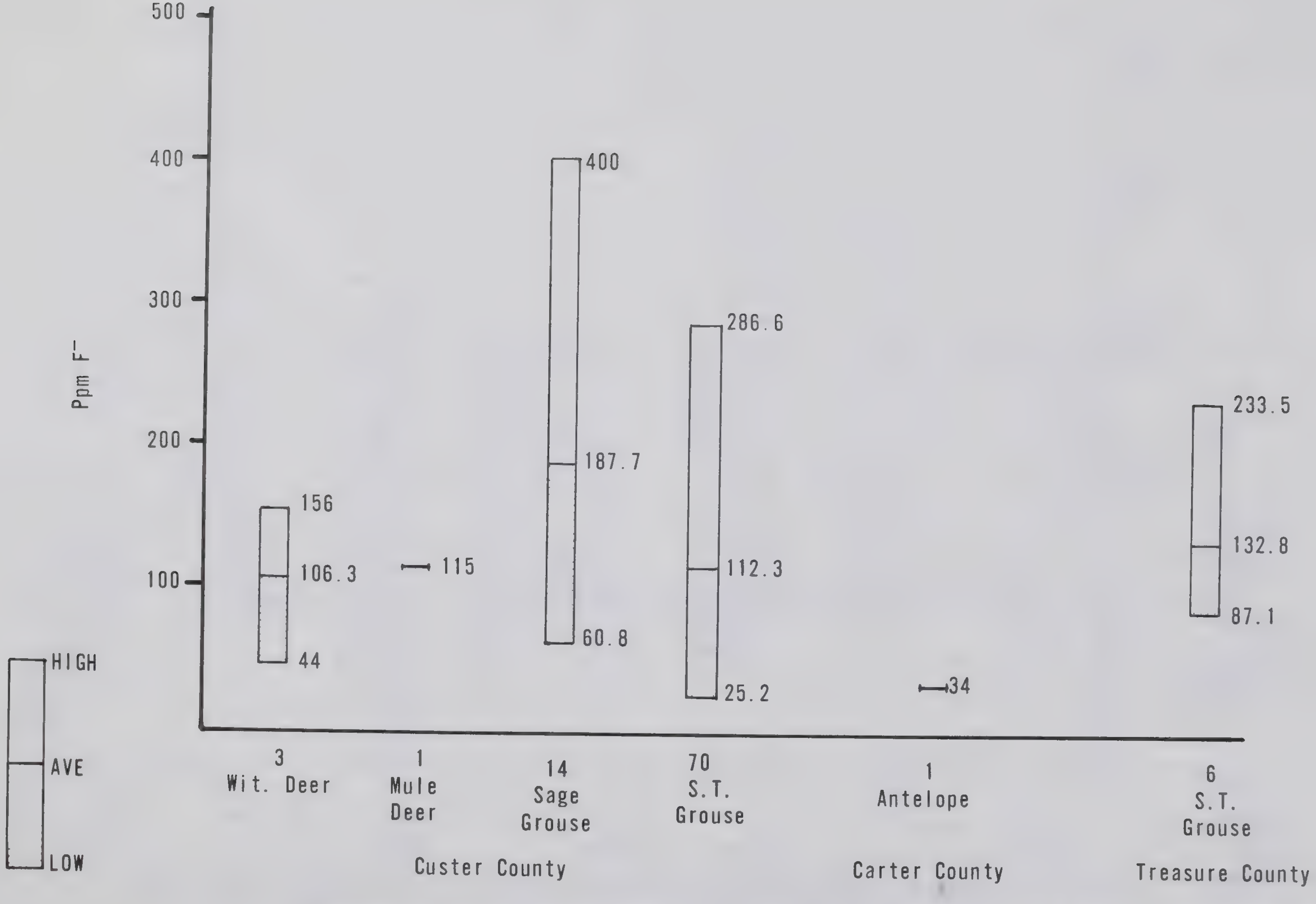
The data in Figure 10-36, from areas of Montana polluted by fluoride, shows an increase in fluoride concentration in mule deer of at least an order of magnitude over those from the Colstrip study area, and an increase of seven times over those from the National Bison Range. The deer mice from Billings, Montana, show an increase of greater than three times over those from Rosebud County. Three mice specimens collected in Rosebud County averaged over 1500 ppm fluoride. These mice were collected in a feed supplement storage shed on the Kluver Family Ranch to show that collections of these animals near human habitation are not representative.

With the exceptions of one short-tailed weasel of unknown age from Rosebud County and the mice specimens from the Kluver Family Ranch, no fluoride levels of animals collected in the study area exceeded 500 ppm fluoride. This is in agreement with studies performed in other areas with other species and with the Sapphire Mountains and National Bison Range populations data included herein. In contrasting Figures 10-31 and 10-32 with the data of Figure 10-36, it can be seen that, with the exception of the whitetail deer from Teakettle Mountain and the deer mice from Billings, the highest fluoride values obtained from the Colstrip study area are less than the lowest fluoride values obtained from fluoride



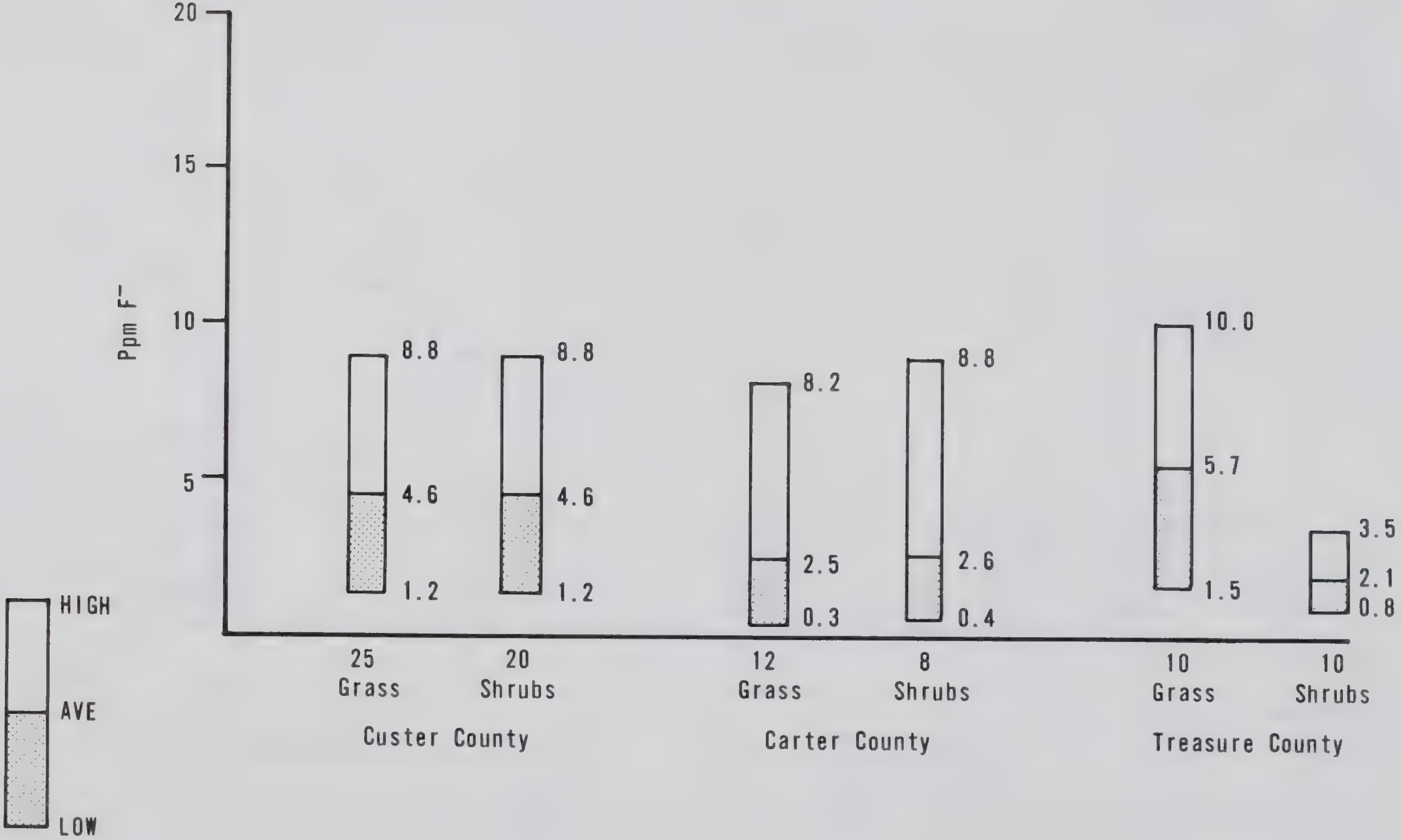
F⁻ Concentration in Animal Bones from Rosebud & Powder River Counties

FIGURE 10-31



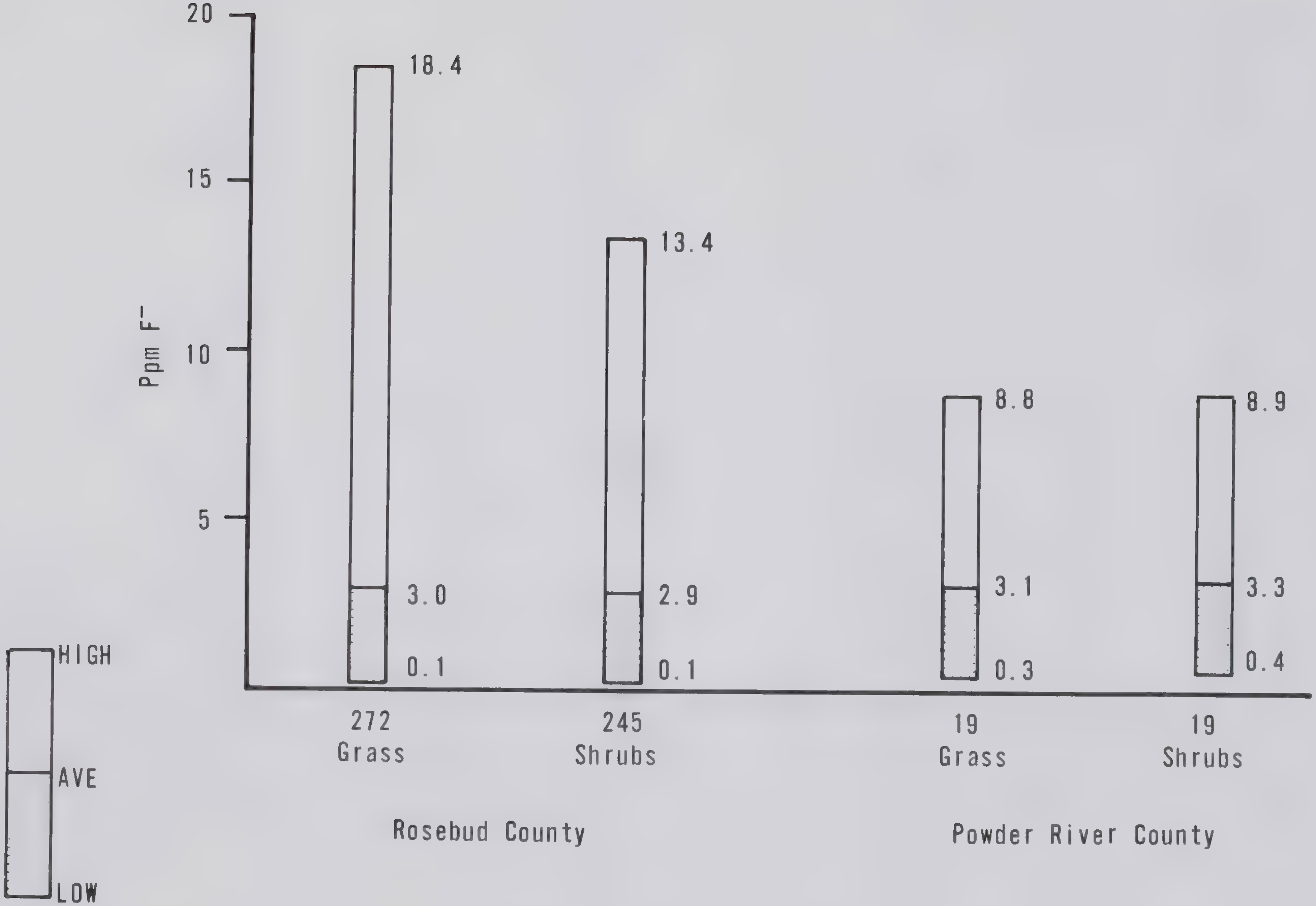
F^- Concentrations in Animal Bones from Custer, Carter and Treasure Counties

FIGURE 10-32



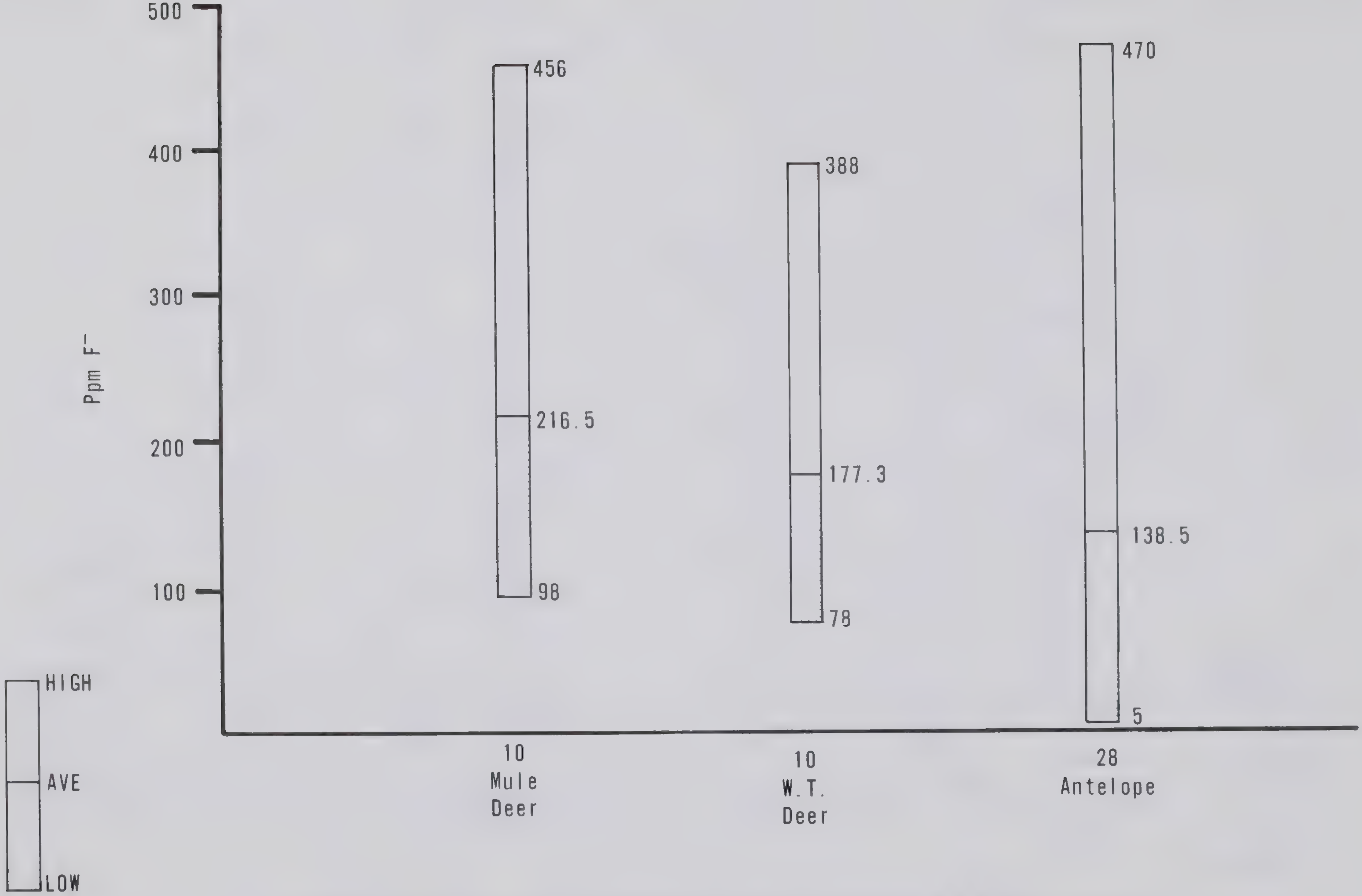
F^- Concentration in Grass & Shrubs from Custer, Carter & Treasure Counties

FIGURE 10-33



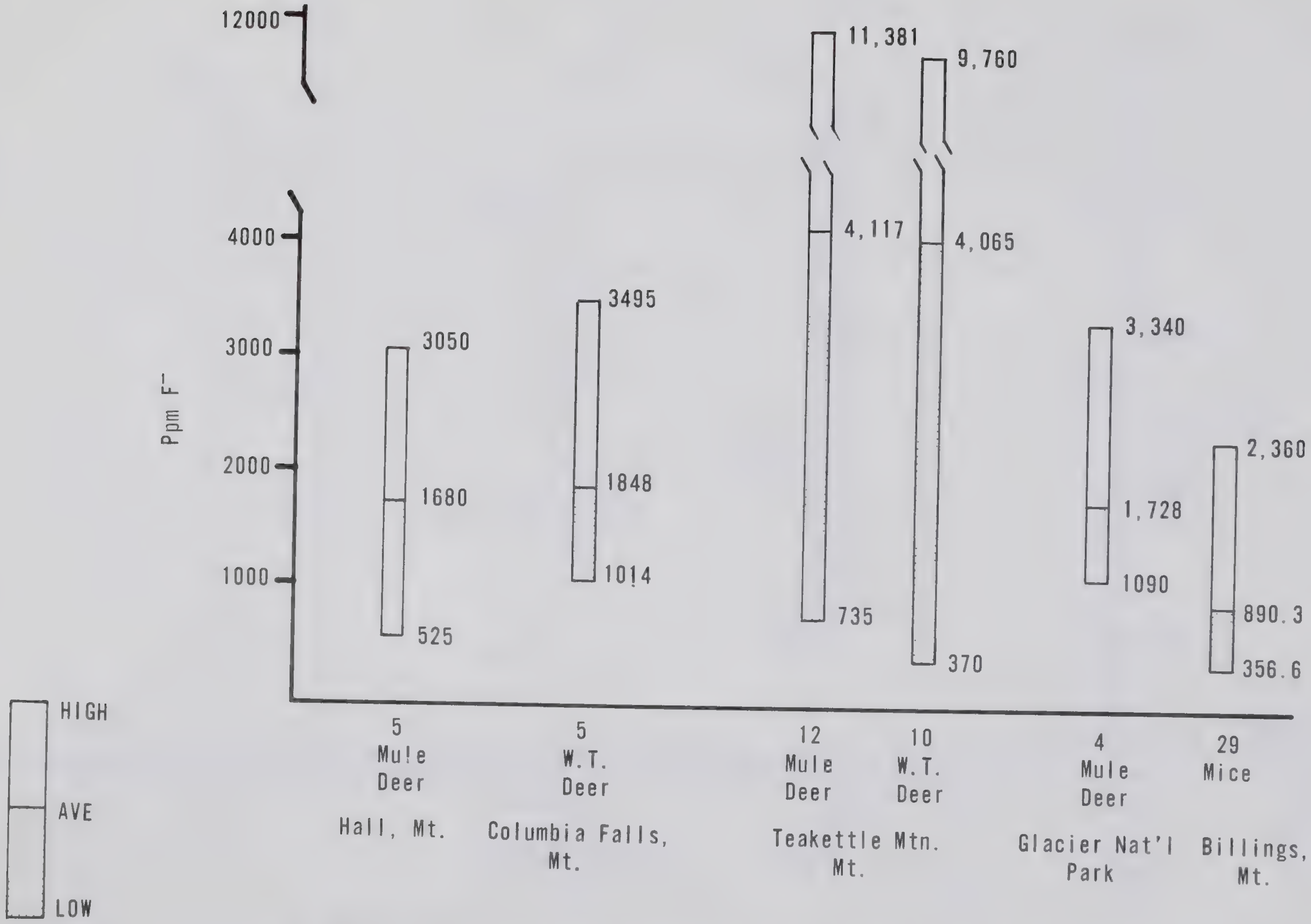
F⁻ Concentration in Grass & Shrubs from Rosebud & Powder River Counties

FIGURE 10–34



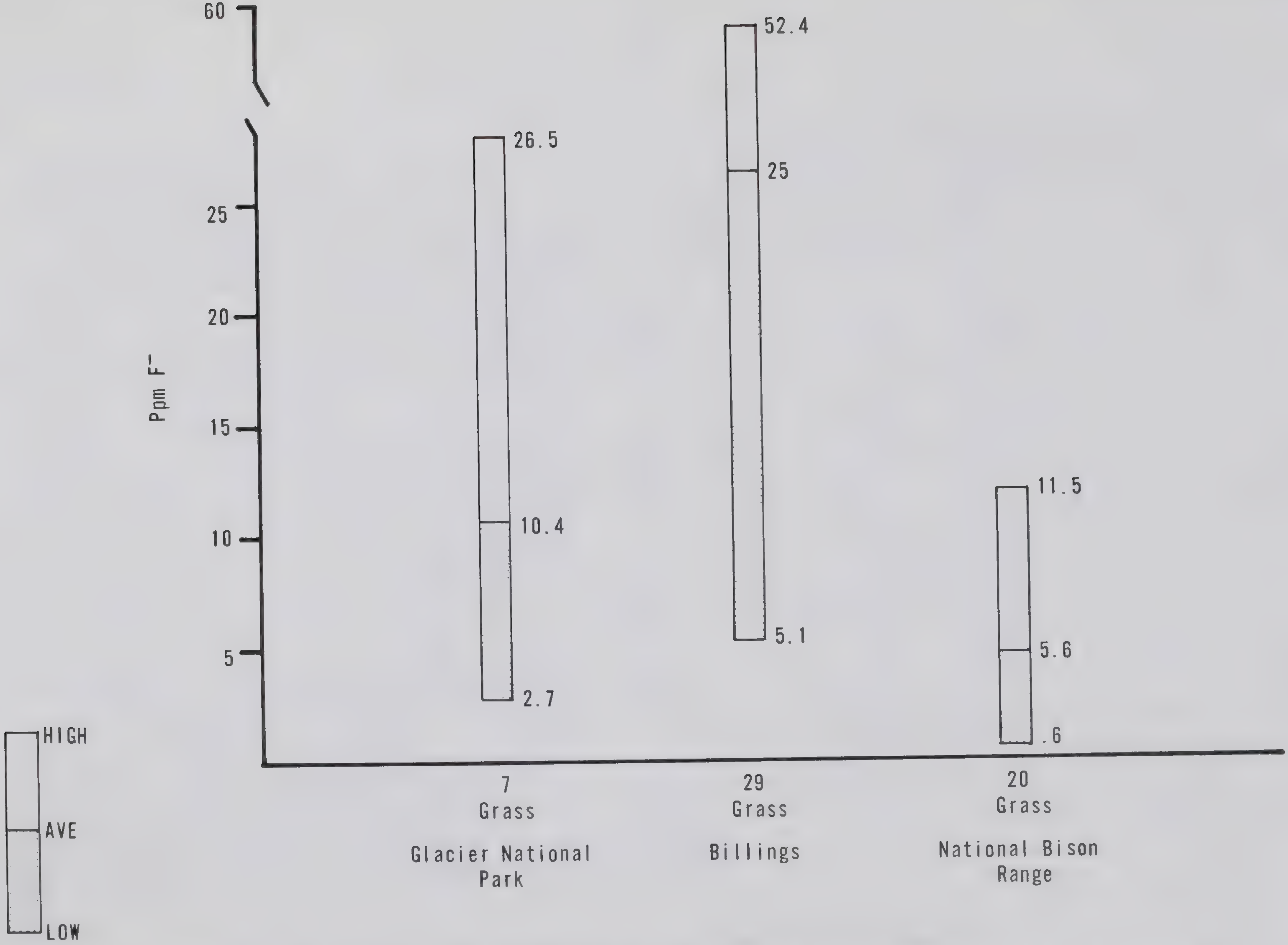
F⁻ Concentration in Animal Bones from the National Bison Range, Montana

FIGURE 10-35



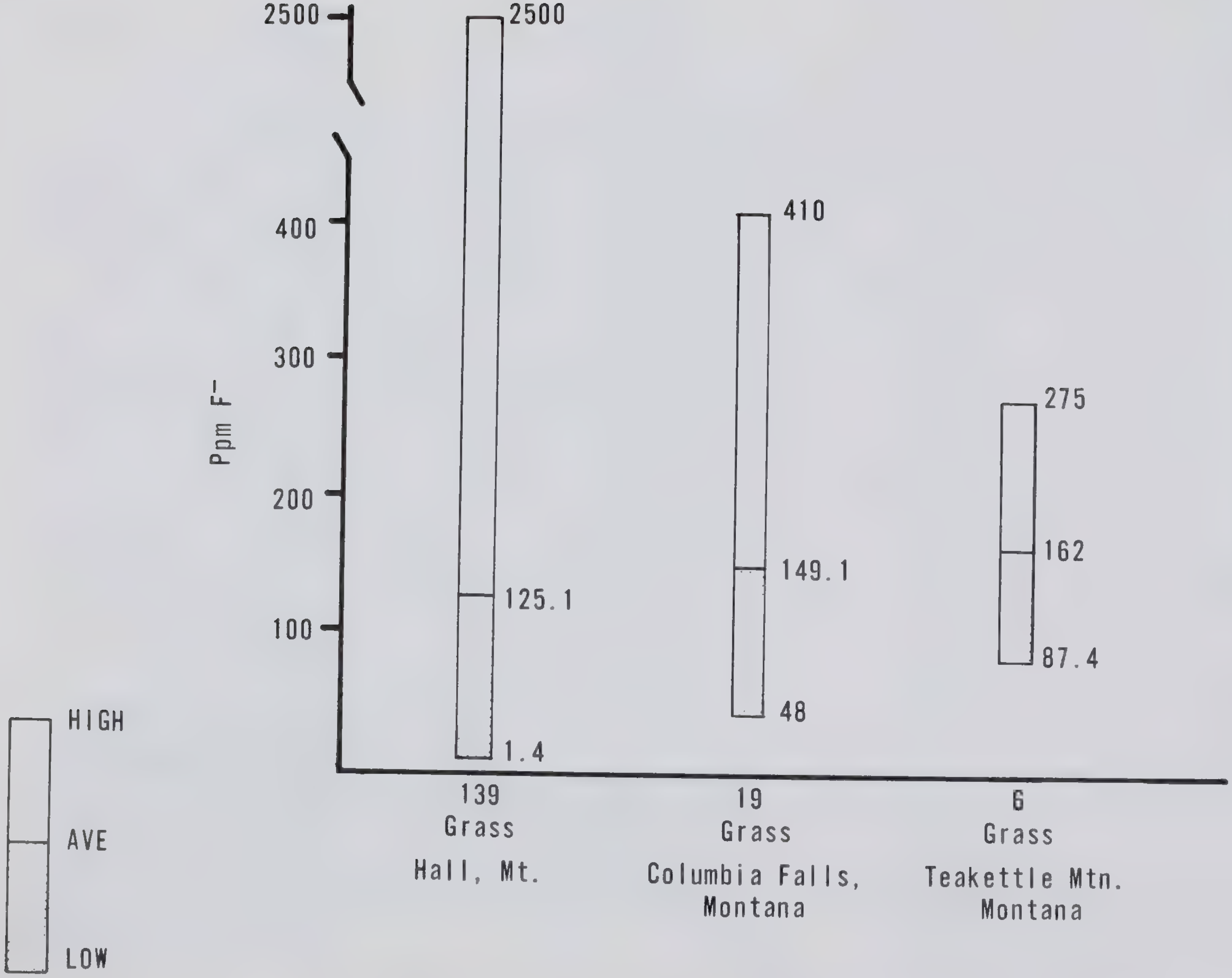
F⁻ Concentration in Animal Bones from Areas in Mt. Polluted by Fluoride

FIGURE 10-36



F⁻ Concentrations in Grass from the National Bison Range, Glacier National Park and Billings, Mt.

FIGURE 10-37



F^- Concentrated in Grass from Areas in Montana Polluted By Fluoride

FIGURE 10-38

polluted areas.

10.1.8.4. Discussion

It is known that under a given ratio of exposure, the fluoride concentration in animal bones increases with age. Preliminary analysis of this phenomenon has been performed with the data obtained from the Sapphire Mountains, the National Bison Range analyses, study area analyses and those reported by Munshower et al. (1974) for deer and antelope. Although the mean fluoride concentration of a population appears to increase with age, there is, in certain cases, considerable variation within a specific age class, and this variation may become more pronounced in the older age classes. These analyses further indicate that the mean fluoride concentration in older age classes in unpolluted areas, however, is still less than 400 ppm fluoride.

Based upon the results reported herein it can be concluded that the Colstrip study area is a true "control" area as of this time for fluoride in vegetation and animals. No clear relationship between vegetation fluoride concentration and animal fluoride concentration can be discerned in the study area except that no fluoride pollution exists. It is known, however, that the main exposure route to animals is through food.

10.1.9. Fisheries

10.1.9.1. Yellowstone River

The Yellowstone River originates in Yellowstone National Park and flows northeast through Montana. It has a total drainage area of approximately 70,400 square miles, 35,900 of which lie in Montana. Its length, from Yellowstone Lake to its confluence with the Missouri River in North Dakota, is 660 miles, 550 of which are in Montana. The Yellowstone is free flowing over its entire length, making it unique among the large rivers of the continental United States.

A detailed study of the Yellowstone River was initiated to provide information on the existing aquatic ecosystem and the potential effects from the MPC complex at Colstrip and associated construction and operation of the water intake structure at Nichols. The major study area was the Yellowstone from Hysham to Miles City, with intensive investigation directly upstream and downstream from the MPC intake structure.

Fishery data from the entire Yellowstone River were included, since withdrawals from sites along the river are likely to have an impact eventually felt throughout the entire system. History has shown that downstream depletions usually lead to upstream manipulations, such as dams, that present their own combinations of environmental problems. In the case of the Yellowstone River, the upstream fishery resource is described, since it cannot be considered immune from the impact of downstream withdrawals.

A. Physical Features

The physical and chemical features of a river are the basis for its biological diversity and productivity. During the course of geologic time, the organisms which have adapted to the extremes of natural variations of the river system are those that have survived. Any changes in the range of natural variations can be detrimental or disastrous.

The following discussion of physical parameters, such as discharge and temperature, will explain the natural regimes in the Yellowstone River to which the aquatic organisms have adapted. Extreme variations are pointed out, since these are probably limiting factors to the biota. Habitat types in relation to channel morphology are discussed, since many aquatic organisms are keyed to specific habitats.

1. Flow Regimes

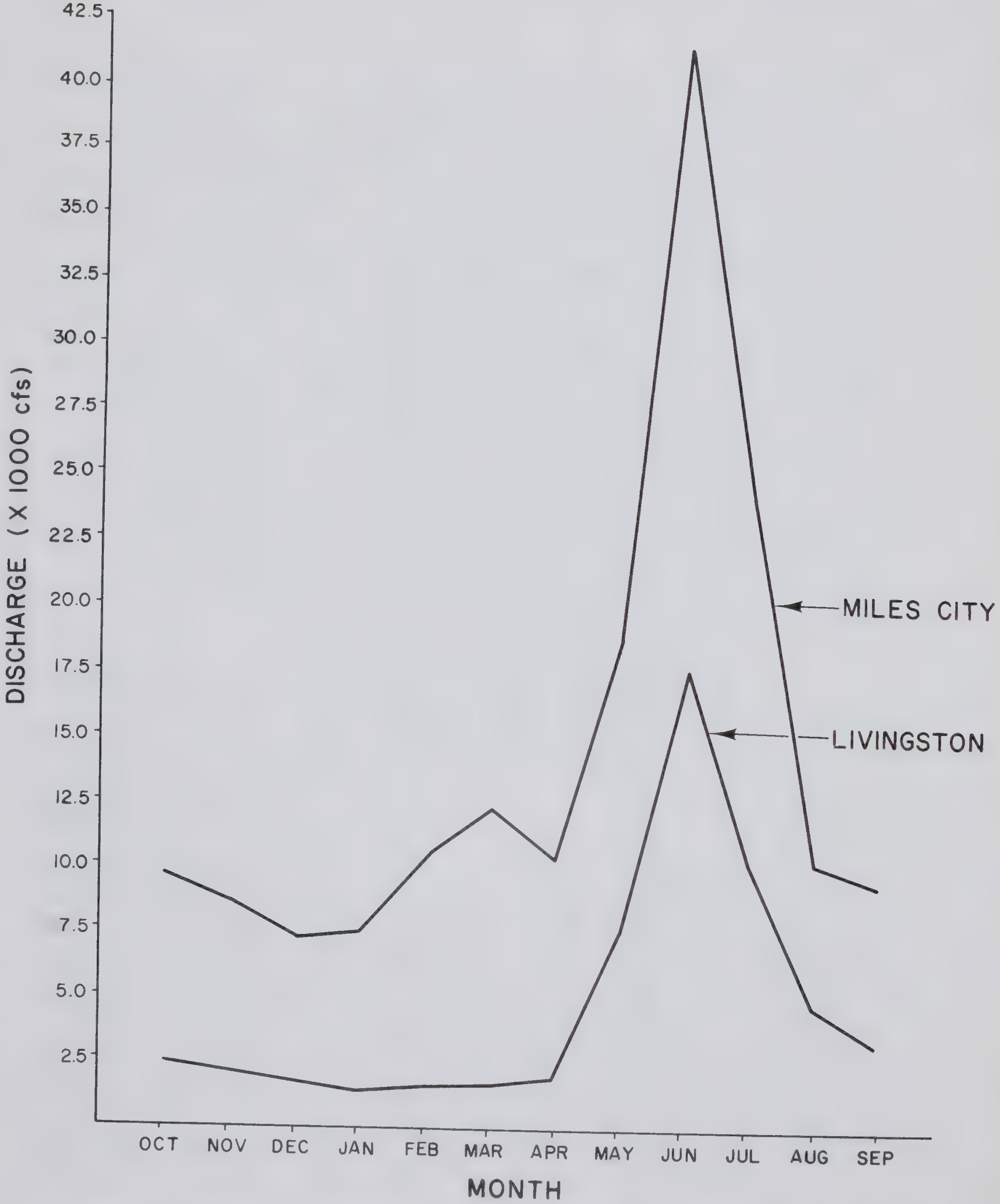
One characteristic of free-flowing rivers that rise in the Rocky Mountains is the great variation between maximum and minimum flows (Reed 1962). Table 10-56 illustrates the variation in discharge during a 10-year recording period. Ratios of maximum to minimum flow ranged from a low of 48 to 1 at Livingston to a high of over 100 to 1 at Billings.

Mean monthly discharge records for a five-year period (1968-1972) at Miles City and Livingston (Figure 10-39) illustrate annual discharge patterns for the lower and upper river. Two peaks of high flow occur at Miles City. The first peak,

TABLE 10-56

Summary of Discharge Data from Four Stations on the Yellowstone River (From USGS, Water Resource Data for Montana, 1963-972).

Station	Mean Monthly	Maximum Observed Discharge: Date & CFS	Minimum Observed Discharge: Date & CFS
Livingston	4,325 cfs	June 23, 1971: 29,200 cfs	March 24, 1964: 610 cfs
Billings	8,208 cfs	June 16, 1967: 64,000 cfs	January 12, 1963: 600 cfs
Miles City	13,279 cfs	June 18, 1967: 71,400 cfs	January 14, 1963: 1,300 cfs
Sidney	14,334 cfs	June 16, 1965: 100,000 cfs	December 18, 1963: 1,000 cfs



ANNUAL DISCHARGE CURVES PLOTTED USING MEAN MONTHLY DISCHARGE VALUES FOR A 5-YEAR RECORDING PERIOD (1968 - 1972) AT LIVINGSTON AND MILES CITY

Figure 10-39

occurring primarily in March, is the lesser of the two and the result of lowland snow melt. The second and major peak occurs during June, when melt water from the mountain headwaters begins to arrive. Low flows occur for a longer period in the upper river due to the absence of lowland runoff. Annual flow conditions are heavily dependent upon snowpack and its rate of thawing in the headwater areas. Spring and summer rainfall may cause small rises of short duration.

Aquatic organisms in the Yellowstone River have, through a long evolutionary process, become dependent upon the natural flow pattern of the river. Over the centuries, fish populations have survived and adapted to both flood and drought. Deposition of silt can eliminate potential spawning areas and reduce the available food producing areas, but increased discharge associated with spring runoff results in a flushing action which removes the deposited sediments and cleanses the interstices. This annual cleansing is an important aspect of the ecology of rivers like the Yellowstone which transport large amounts of sediment.

2. Water Temperatures

Two water temperature cycles occur in the Yellowstone River, the annual and the diurnal (daily). Both of these cycles show a greater mean variation downstream. Maximum recorded water temperatures range from 68°F at Livingston to 84°F at Sidney (Table 10-57) and usually occur during late July to early August.

Table 10-57

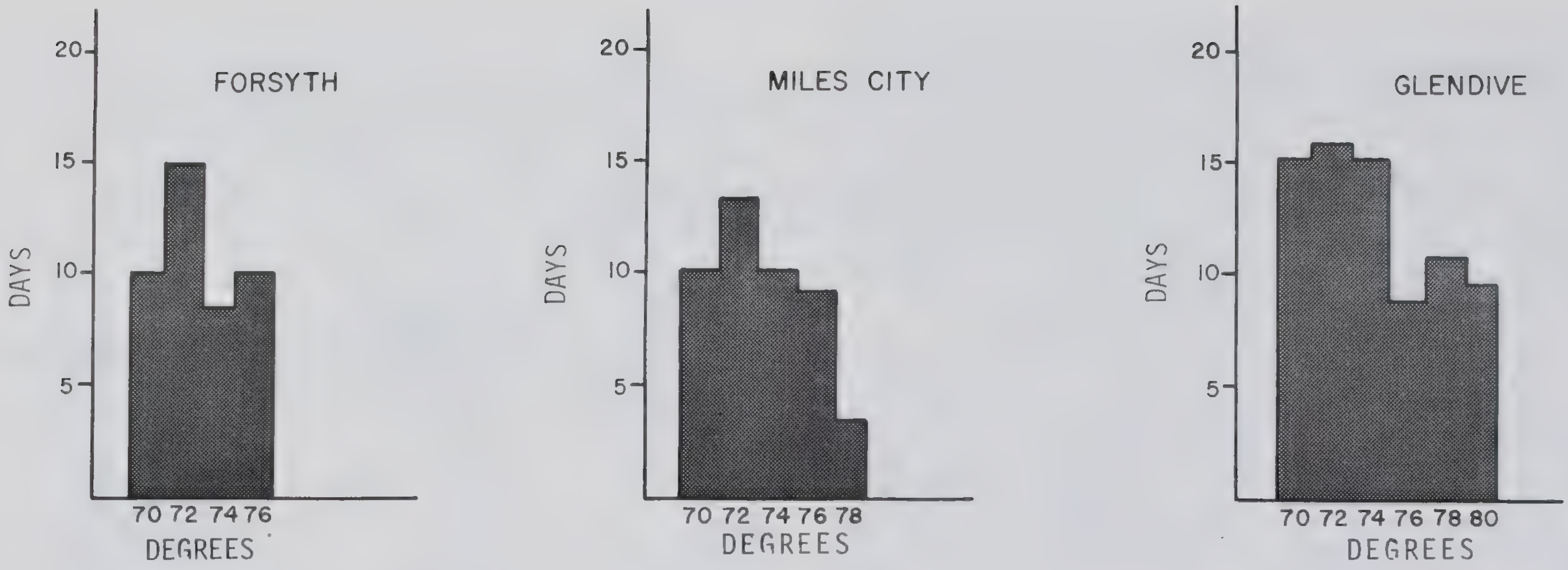
Observed Maximum Water Temperatures for Four Recording Sites on the Yellowstone River (Data from Aagaard 1969).

Location	Maximum Observed Temp.°F	Date of Occurrence
Livingston	68	July 18, 1955
Billings	80	July 24, 1955
Miles City	83	August 4, 1960
Sidney	84	July 23, 1960

Temperatures in excess of 70°F occur for extended periods in the river below Billings (Figure 10-40).

Monthly temperature data for Livingston and Forsyth are summarized in Table 10-58.

Temperature data for Livingston and Forsyth were of sufficient detail to show distinct diurnal variations. These variations were not detectable during winter months, but were distinct from April through October. The maximum daily variations for a 24-hour period were 9°F at Livingston and 5°F at Forsyth, although mean diurnal temperature variations showed a slightly greater variation at Forsyth (Table 10-59). Daily temperature variations tended to follow air temperatures and usually reached a maximum in late afternoon and a



MAXIMUM WATER TEMPERATURE PROFILES FOR THE YELLOWSTONE RIVER (1972) SHOWN AS THE NUMBER OF DAYS WHEN WATER TEMPERATURE EXCEEDED 70°F. (ELSER 1973).

Figure 10-40

TABLE 10-58

Mean Monthly Maximum and Minimum Temperatures for Two Recording Stations on the Yellowstone River

Month	Livingston (1954-1963)*1/ Mean Mo. Max. (°F)	Livingston (1954-1963)*1/ Mean Mo. Min. (°F)	Forsyth (1970-1974)**2/ Mean Mo. Max. (°F)	Forsyth (1970-1974)**2/ Mean Mo. Min. (°F)
October	50	48	49 3/	47
November	41	39	40 4/	39
December	37	36	34 4/	33
January	35	34	32 5/	32
February	37	36	33 6/	33
March	41	39	41	38
April	48	45	48	45
May	51	49	56	54
June	53	51	63 7/	60
July	62	59	71 7/	67
August	63	60	74 7/	71
September	56	54	61 7/	58

1/ *Livingston data from Aagaard (1969)
2/ ** Forsyth data from Montana Department of Fish and Game
3/ Missing 8 days in 10/70 and all of 10/74
4/ Missing 1970 and 1974
5/ Missing 16 days in 1/70 and 18 days in 1/71
6/ Missing 16 days in 1/70
7/ Missing 1974

minimum in early morning.

Table 10-59

Mean Daily Temperature Variation (F°) from April to October for Two Yellowstone River Recording Stations

Month	Livingston*[5] (10 years: 1954-1963)	Forsyth**[6] 4 years: 1970-1973)
April	2.34	2.48[2]
May	2.37[1]	2.38[3]
June	2.14[2]	2.67
July	2.79[2]	3.29
August	2.78	3.43[2]
September	2.13	3.03[4]
October	1.65	2.14[4]

[1] Missing - 7 days
[2] Missing - 1 day
[3] Missing - 2 days
[4] Missing - 8 days
[5] *Livingston data from Aagaard (1969)
[6] **Forsyth data from Montana Department of Fish and Game

Thermal stratification of the Yellowstone probably does not occur, since temperature homogeneity is common for large, swift-flowing rivers in the main channels (Hynes 1970). However, considerable temperature differences may occur between backwater areas or slow-moving side channels and the main channels. Increased diurnal changes and higher mean temperatures also probably occur in slow-moving side channels and backwater areas.

3. Channel Morphology and Habitat Types

The distribution, abundance and variety of fish habitat types depend largely on channel morphology and flow characteristics of the river system. Morphological parameters important in determining fish habitat types are sinuousity, bottom type, velocity, and number of islands and shoreline miles in a given section of river.

Many fish species are restricted to specific habitats, while others utilize several habitat types. In determining effects of altered flows on fish populations, it is important to identify critical habitat types and their associated biota. General habitat types identified in the lower river include main channel areas, side channels, backwater areas and confluences with tributary streams.

Main channel areas are usually deep and wide, with relatively high velocities, and contain the major portion of the flow. Large pool and riffle areas are found within the main channel.

Side channels usually carry considerably less water and may become dry or cut off, forming backwaters during low flow. The upstream end of most side channels is characterized by a shallow riffle with a high velocity and associated rubble substrate. The middle and lower portions of side channels exhibit reduced water velocities which induce higher deposition rates and result in a sand or silt substrate. Side channels also exhibit pool and riffle zones.

Backwaters are areas with no currents and are formed mainly by cut off side channels and the mouths of dry tributaries. These backwaters have a sand and silt substrate.

Within the general habitat types are specific microhabitats determined by substrate, velocity, depth, and, in some cases, cover. These general habitat types are not constant and vary with flow conditions. Depths and areas of main and side channels, formation and extent of backwater areas, and other features are dependent on velocities and stage heights.

The river channel between Hysham and Fallon has sinuousity values ranging from 1.42 to 1.14 (Table 10-60). The Hysham and Forsyth sections approach what Leopold et al. (1964) consider a meandering stream (sinuousity of 1.5 or greater). The Hathaway and Fallon sections exhibit lower sinuousity values, but still have considerable number of islands and shoreline area. The degree of sinuousity, presence of associated side channels and backwaters, and large number of islands and shoreline areas in these sections provide for a diversity of habitat types.

B. Biota

1. Fish

A total of 49 fish species have been recorded for the Yellowstone River in Montana (Table 10-61) (see also Section d, "Annotated List of Species"). There is an increase in species diversity progressing downstream. Intensive sampling in the Yellowstone between Gardiner and Livingston yielded 11 species representing 4 familes, and sampling between Hysham and Miles City yielded 39 species representing 12 families.

The Yellowstone can be divided into three areas relating to fish distribution. The upper Yellowstone, from Gardiner to Big Timber, supports a cold-water fishery of national significance and has been classified as a blue ribbon trout stream by the Montana Fish and Game Commission. The middle reach, from Big Timber to the mouth of the Bighorn River, contains a variety of both cold and warm water species. Downstream from the mouth of the Bighorn, the river supports a diverse warm water fishery.

a. Upper Yellowstone

The upper Yellowstone River extends from Gardiner to Big Timber. Game fish species found in the upper river include mountain whitefish and rainbow, brown, and cutthroat, trout. Nongame species include longnose, white, and mountain suckers, longnose dace, mottled sculpin, carp, shorthead redhorse (Peterman 1974b), goldeye, and lake chub (Brown 1971 c)

i. Investigations

Fish populations have been sampled in various areas of the Yellowstone (Figure 10-41). The section between Gardiner and Springdale has been under study for several years by the Montana Department of Fish and Game. The most recent and detailed investigation of that section of river is part of the Department's Upper Yellowstone and

TABLE 10-60

Physical Parameters for Four Sections of the Lower Yellowstone River

River Section1/	Number of Islands2/	Sinuousity3/	Shoreline (Miles)	Mainstream Length (Miles)	Down Valley Dist. (Miles)4/
Hysham1/	32	1.42	72.2	14.3	10.14
Forsyth5/	58	1.37	116.3	26.7	19.46
Hathaway1/	24	1.24	45.9	12.9	10.63
Fallon1/	17	1.14	41.5	13.7	11.97

1/ River sections defined and studies by Hinz (1974)
2/ Figure subject to change due to change in river channel
3/ Ratio of mainstream length to down valley distance
4/ Straight-line distance between the endpoints of a given section
5/ Measured from the mouth of Reservoir Creek to the mouth of Rosebud Creek

TABLE 10-61. Fish Species Recorded for the Yellowstone River (Family, Scientific and Common Names).

ACIPENSERIDAE (Sturgeon family)

Scaphirhynchus albus	Pallid sturgeon*
Scaphirhynchus platorynchus	Shovelnose sturgeon*

POLYODONTIDAE (Paddlefish family)

Polyodon spathula	Paddlefish*

HIODONTIDAE (Mooneye family)

Hiodon alosoides	Goldeye*

SALMONIDAE (Trout family)

Prosopium williamsoni	Mountain whitefish*
Salmo clarki	Cutthroat trout*
Salmo gairdneri	Rainbow trout*
Salmo trutta	Brown trout*
Salvelinus fontinalis	Brook trout*

ESOCIDAE (Pike family)

Esox lucius	Northern pike*

CYPRINIDAE (Minnow family)

Cyprinus carpio	Carp*
Carassius auratus	Goldfish*
Notemigonus crysoleucas	Golden shiner*
Semotilus margarita	Pearl dace
Semotilus atromaculatus	Creek chub
Hybopsis gracilis	Flathead chub*
Hybopsis gelida	Sturgeon chub
Couesius plumbeus	Lake chub
Notropis atherinoides	Emerald shiner*
Notropis stramineus	Sand shiner
Hybognathus hankinsoni	Brassy minnow
Hybognathus placitus	Plains minnow
Hybognathus nuchalis	Silvery minnow*
Pimephales promelas	Fathead minnow*
Rhinichthys cataractae	Longnose dace*

*Species taken in recent sampling

CATOSTOMIDAE (Sucker family)

Carpoides carpio	River carpsucker*
Cycleptus elongatus	Blue sucker*
Ictiobus bubalus	Smallmouth buffalo*
Ictiobus cyprinellus	Bigmouth buffalo*
Moxostoma macrolepidotum	Shorthead redhorse*
Catostomus catostomus	Longnose sucker*
Catostomus commersoni	White sucker*
Catostomus platyrhynchus	Mountain sucker*

ICTALURIDAE (Catfish family)

Ictalurus melas	Black bullhead*
Ictalurus punctatus	Channel catfish*
Noturus flavus	Stonecat*

GADIDAE (Codfish family)

Lota lota	Burbot*

CENTRARCHIDAE (Sunfish family)

Lepomis cyanellus	Green sunfish*
Lepomis gibbosus	Pumpkinseed
Lepomis macrochirus	Bluegill
Micropterus dolomieui	Smallmouth bass*
Micropterus salmoides	Largemouth bass*
Pomoxis annularis	White crappie*
Pomoxis nigromaculatus	Black crappie*

PERCIDAE (Perch family)

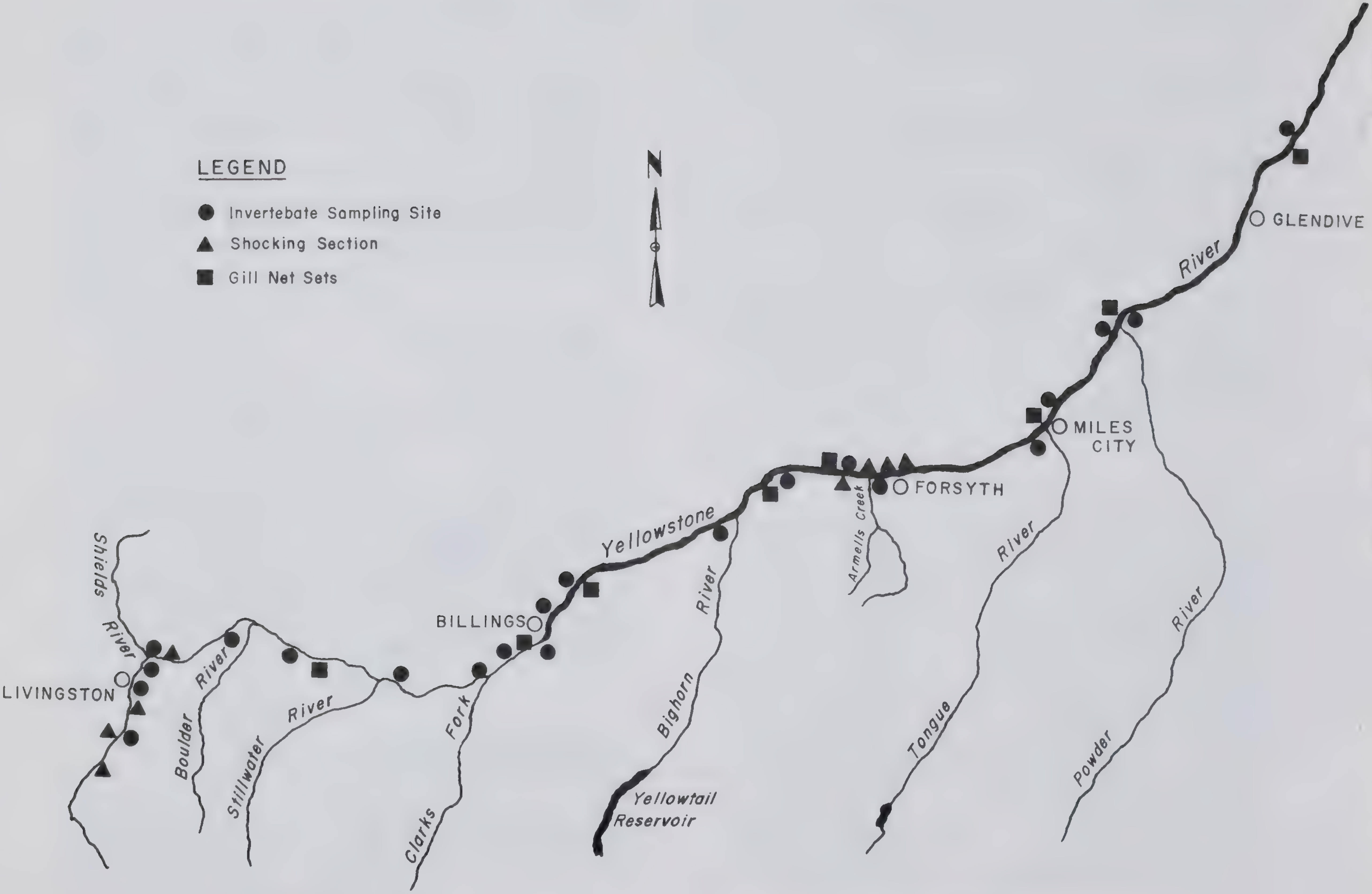
Perca flavescens	Yellow perch*
Stizostedion canadense	Sauger*
Stizostedion vitreum	Walleye*

SCIAENIDAE (Drum family)

Aplodinotus grunniens	Freshwater drum*

COTTIDAE (Sculpin family)

Cottus bairdi	Mottled sculpin*



YELLOWSTONE RIVER DRAINAGE IN MONTANA ILLUSTRATING FISH AND AQUATIC INVERTEBRATE SAMPLING LOCATIONS.

Figure 10-41

Shields Rivers Planning and Inventory Study. That study, in progress, is designed in part to monitor the southeastern Montana coal development as it relates to watershed demands on the upper Yellowstone drainage and other present and future demands affecting the resource (Peterman 1974b).

Fish populations in the upper river were inventoried by electrofishing with a mobile electrode unit. Methods used for computation of population estimates, age structure, and confidence intervals followed those described by Vincent (1971).

ii. Results

Population estimates (spring and fall 1970) for a 4.2 mile section of the Yellowstone River immediately upstream from Livingston (Table 10-62) revealed standing crops of 386 wild rainbow and brown trout (Age II and older) per 1000 feet of river in the spring and 735 (Age I and older) per 1000 feet in the fall (Elser and Marcoux 1971). Weights for the two sampling periods were 265 and 522 pounds per 1000 feet of river, respectively. Rainbow trout predominated numerically, making up 58.2% in the spring and 65.6% in the fall. By weight, rainbows comprised 62.3 and 60.5% of the total for spring and fall, respectively.

The Yellowstone cutthroat is native to the upper Yellowstone drainage. Historical fisheries data are lacking; however, at one time thriving populations of cutthroat apparently existed there. Today, the only portion of the Yellowstone River containing cutthroat as the sole trout species lies in Yellowstone National Park above Tower Junction. In the Yellowstone River in Montana, the cutthroat is by far the least numerous of the trout species present (Peterman 1974b).

The mountain whitefish is native to Montana and occurs throughout the upper Yellowstone River. These are of suitable size for sport fishing and are the most abundant game fish species in all areas of the upper river sampled. Whitefish numbers were estimated in three sections of the upper river in the vicinities of the Emigrant, Mallard Rest, and Sheep Mountain fishing access sites—and revealed standing crops (Age III and older) of 3,062, 2,252 and 2,012 whitefish per 1,000 feet of river, respectively (Table 10-63). Pounds of whitefish (Age III and older) per 1,000 feet of river were 1,341 at Emigrant, 1,180 at Mallard Rest and 1,349 at Sheep Mountain (Peterman 1974b).

The longnose sucker is native to Montana and occurs in large numbers in the Yellowstone River throughout the upper reaches. An estimate of longnose sucker numbers and biomass was obtained on a section of river near Emigrant. The standing crop of longnose suckers in this section in March 1973 was found to be 1,010 fish and 2,221 pounds per 1,000 feet of river (Table 10-63). In this section, the longnose suckers comprised the estimated estimated fish biomass, but were second in abundance numerically. White and mountain suckers were present, but not in large enough numbers to estimate (Peterman 1974b).

iii. Fishing Pressure

In 1968, the Department of Fish and Game

Table 10-62

Estimated Fish Populations From the Yellowstone River, April and October 1970, Expressed as Number per 1,000 Feet of Stream. Pounds per 1,000 Feet are shown in Parentheses (Elser and Marcoux 1971).

Age Group	Rainbow Trout		Brown Trout	
	Spring	Fall	Spring	Fall
I[1]		152 (36)		91 (23)
II[2]	142 (62)	199 (123)	103 (33)	85 (61)
III[3]	63 (67)	107 (111)	41 (37)	53 (71)
IV+[4]	20 (36)	24 (46)	17 (30)	24 (51)
Total Two std. dev.	225 (165) +81*	482 (316) +255*	161 (100) + 65*	253 (206) + 73*

* Based on 95 percent confidence interval

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[1] One Year Old
[2] Two Year Old
[3] Three Year Old
[4] Four Years and Older

Table 10-63

Mountain Whitefish and Longnose Sucker Population Estimates for Three Sections of the Upper Yellowstone River, March 1973.

Age Class	Mean Length (inches)	Mean Weight (pounds)	Estimated Number	Estimated Weight (pounds)
MOUNTAIN WHITEFISH				
		Emigrant Section (4,686 ft.)		
II	8.2	0.17	4307	731
III	10.4	0.36	9149	3268
IV	12.3	0.53	4613	2427
V & Older	15.0	1.00	589	590
		Total	18658 (± 2757)*	7016 (± 699)*
		Mallard Rest Section (7,524 ft.)		
III	10.9	0.42	7473	3128
IV	12.4	0.59	9183	5388
V & Older	16.0	1.26	290	364
		Total	16946	8880
		Sheep Mountain Section (4,026 ft.)		
III	11.6	0.47	3225	1526
IV	13.3	0.68	3525	2409
V & Older	15.4	1.11	1354	1498
		Total	8104	5433

Table 10-63
(cont.)

Age Class	Mean Length (inches)	Mean Weight (pounds)	Estimated Number	Estimated Weight (pounds)
LONGNOSE SUCKER				
		Emigrant Section (4,686 ft.)		
IV & Older	17.3	2.20	4735 (± 1380)*	10408 (± 3034)*

* 80% Confidence Interval in Parenthesis Were Calculated.

determined statewide fishing pressure estimates by mail survey. The pressure survey covered the fishing license year from May 1, 1968, to April 30, 1969. Results from the survey revealed a total of 35,346 angler days expended on the Yellowstone River from Gardiner to the mouth of the Shields River from May 1 through September 30, 1968. The winter fishery, October 1, 1968, through April 30, 1969, contributed an additional 9,466 angler days in the same area.

Rainbow and brown trout, although not native to the upper Yellowstone, now provide the bulk of the trout fishery and harvest.

b. Middle Yellowstone

i. Investigations

The middle Yellowstone extends from Big Timber to the mouth of the Bighorn River. This portion of the river contains both cold and warm water species and represents the transition zone between the upper cold water and lower warm water environments. Sampling in the vicinity of Reed Point was done with 125-foot graduated mesh (3/4- to 2-inch) experimental gill nets set for approximately 24 hours and by electrofishing with the mobile electrode unit (Peterman unpublished data). Overnight gill net sets were used exclusively to sample the Yellowstone from Laurel to the mouth of the Bighorn River (Marcuson 1974).

ii. Results

Six overnight gill net sets and limited electrofishing in the vicinity of Reed Point resulted in the capture of 11 species, including rainbow and brown trout, mountain whitefish, longnose, white and mountain suckers, stonecat, shorthead redhorse, burbot, longnose dace, and mottled sculpin (Peterman unpublished data).

A total of 39 overnight gill net sets were made in the Yellowstone from Laurel downstream to the Bighorn River (Table 10-64). Six brown and two rainbow trout were captured in five nets in the river from the Highway 212 bridge at Laurel to the confluence of the Clarks Fork of the Yellowstone River and the east bridge in Billings captured ten brown and one rainbow trout. Between the east bridge and the Huntley Diversion Dam to the mouth of the Bighorn River produced no trout, but 12 channel catfish and 16 sauger were taken in 12 net sets. (Marcuson 1974).

c. Lower Yellowstone

i. Investigations

On the lower Yellowstone, below the mouth of the Bighorn River, several fish collecting tools were utilized, including 125-foot graduated mesh (3/4- to 2-inch) experimental gill nets, 300-foot graduated mesh ($2\frac{1}{2}$ to 4-inch) gill nets, hoop nets, seines, set lines, the mobile electrode unit and a boom-type electrofishing unit. The 125-foot experimental gill nets were used during both spring and fall sampling to inventory the species present and provide data on species distribution. These nets were usually set for a period of between 18 to 24 hours and limited to areas of relatively low current velocities. A 100-foot, $\frac{1}{4}$-inch mesh seine was used in selected areas.

Table 10-64

Summary of Overnight Gill Net Sets for Four Areas of the Middle Yellowstone River 1970-1973
Expressed as Fish per Net Set
(Data from Marcuson 1974)

Species	Laurel to mouth of Clarks Fork 5 Nets	Mouth of Clarks Fork to Billings 16 Nets	Billings to Huntley 6 Nets	Huntley to Mouth of Bighorn River 12 Nets
Goldeye	4.40	6.31	1.83	17.50
Mountain whitefish	.40	.19	.17	
Rainbow trout	.40	.06		
Brown trout	1.20	.63	.83	
Carp		.13		.25
Flathead chub		2.63	1.17	.08
River carpsucker		.44		.33
Shorthead redhorse	.40	.56	.17	.83
Longnose sucker	2.20	1.19	.83	.25
White sucker	3.20	6.69	17.33	1.33
Black bullhead	.60	1.13		
Channel catfish				1.00
Stonecat				.17
Burbot	.80	.06		.17
Sauger		.06		1.33
Total	13.60	20.08	22.33	23.24

The boom electrofishing unit consisted of electrodes suspended in front of the boat by 16-foot fiberglass poles, a 4,500 watt generator, and a Coffelt variable voltage pulsator. Population estimates for two one-mile sections of the Yellowstone near Forsyth were obtained using the modified Schnabel multiple mark and recovery method (Ricker 1958).

Investigations into angler harvest, movements, and life history of the paddlefish in the lower river were initiated in 1964 by the Department of Fish and Game and are continuing (Elser 1974a).General fisheries inventory work was begun on the lower river in the spring of 1973 in the vicinity of the MPC intake structure near the mouth of Armells Creek. The initial investigations were conducted during two periods, March 28-30 and May 2-4, 1973. Sampling was intense, but lacked extensiveness and seasonal coverage. Fisheries investigations were continued in August 1973 to assess the impacts of potential water withdrawals for Colstrip Units 3 and 4. These investigations concentrated in the area between Hysham and Miles City, with limited sampling in the vicinity of Terry and Intake.

ii. Results - Gill Net Sets

a) Spring 1973

During the first sampling period in March of 1973, 31 overnight gill net sets produced 13 species with an average catch of 37.7 fish per net set. The second sampling, May 1973, produced 13 species from 10 net sets with an average catch rate of 67.9 fish per set. Goldeye were the dominant species in the catch during both sampling periods, contributing 29.4 and 57.5 fish per net, respectively (Table 10-65).

A comparison of fish collections from main channel and backwater areas indicated a greater abundance and diversity of catch in the latter. Average fish per net set in backwaters was 51.2, as compared to 1.3 fish per set in main channel areas. This difference probably reflects the difference in the efficiency of gill nets fished in these areas. The average catch rates in the second period were higher than the first, possibly due to the comparatively inefficient main stream sets used only during the first sampling period. Comparing backwater sets only, the average number of fish per net set was 52.7 for the March sampling and 67.9 for the May sampling.

Average lengths and weights for the combined March and May gill net sets are presented in Table 10-66.

b) Fall 1973

During the fall of 1973, five areas of the lower Yellowstone were sampled with 89 gill net sets. The areas sampled were in the vicinities of Hysham, Forsyth, Miles City, Terry, and Intake, with 15, 24, 33, 6, and 11 nets being set in each area, respectively. Nets were set in a variety of river habitats including main channels, backwaters, creek mouths, and side channels, in quiet waters and in association with various current velocities.

A total of 3678 fish of 23 species was taken for all fall gill net samples, with an average catch rate of 41.33 fish per net set. Goldeye

Table 10-65

Summary of Gill Net Samples from the Yellowstone River near Armells Creek, 1973
Expressed as the Average Number of Fish per Net Set
(Elser 1974)

Species	March 28-30	May 2-4
Goldeye	29.38	57.50
Northern pike	0.05	
Carp	0.09	1.10
Flathead chub	0.09	0.60
River carpsucker	3.76	2.20
Smallmouth buffalo	1.05	0.70
Shorthead redhorse	0.80	1.40
Longnose sucker	0.14	
White sucker	0.19	0.50
Mountain sucker		0.10
Channel catfish	0.52	2.30
Stonecat	0.48	0.30
Burbot	0.24	0.30
Black crappie		0.10
Sauger	0.86	0.80
Total	37.65	67.90

Table 10- 66

Average Lengths and Weights for Fish from 41 Overnight Gill Net Sets from near Armells Creek, Spring 1973.

Species	Number	Percent of Total	Average Length (Inches)	Average Weight (Pounds)
Goldeye	1,192	81.0	11.9	0.5
Northern pike	1	Tr[1]	24.0	4.8
Carp	13	0.9	15.6	2.0
Flathead chub	8	0.5	7.2	0.2
River carpsucker	101	6.9	14.3	1.3
Smallmouth buffalo	29	2.0	25.7	6.4
Shorthead redhorse	31	2.1	15.0	1.4
Longnose sucker	3	Tr[1]	15.8	1.6
White sucker	9	0.7	15.7	1.7
Mountain sucker	1	Tr[1]	6.3	0.1
Channel catfish	34	2.3	15.6	3.9
Stonecat	15	10.0	7.6	0.2
Burbot	7	0.5	17.7	1.0
Black crappie	1	Tr[1]	4.4	0.1
Sauger	26	1.8	14.2	0.9
Total	1,471			

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[1] Trace

dominated the total catch, accounting for 69.5%, while channel catfish, river carpsucker, and sauger made up 10.4%, 6.7%, and 4.7% of the total catch, respectively (Table 10-67).

The Hysham section, with an average catch rate of 57.98 for 15 gill net sets, was considerably higher than the Forsyth, Miles City and Intake sections, but slightly lower than the Terry section. Thirteen species were taken in the Hysham section during the sampling period. The average catch rates of 7.13 per net for channel catfish was the highest for all sections, and the average sauger catch rate of 1.13 was the lowest for all sections (Table 10-67). Goldeye accounted for 72.2% of the total, channel catfish accounted for 12.3% (Table 10-68).

A total catch rate of 35.38 fish per net for 24 net sets in the Forsyth section was lower than all but the Intake section. Seventeen species, the highest number for all sections, were taken, (Table 10-67). Goldeye were the most abundant, making up 54.2% of the total, followed by channel catfish, making up 14.1% (Table 10-69). Average size for sauger in this section was larger than in all other sections.

Thirty-three net sets produced a catch rate of 38.47 fish per net for the Miles City section. Sixteen species were taken in this section, (Table 10-67). Seventy-five point seven percent of the catch was goldeye, followed by channel catfish which made up 9.6% (Table 10-70).

The Terry section with six net sets, had the highest average catch rate for all sections, 61.51 fish per net (Table 10-67). Fourteen species were taken, including the only rainbow trout. The catch was dominated by goldeye, which comprised 80.8% of the total (Table 10-71). The average catch rates for sauger, goldeye, river carpsucker, white sucker and white croppies, were the highest for all sampling sections (Table 10-67).

The Intake section, with 11 net sites, had the lowest average catch rate, 29.07 per net, of all sections, but the highest catch rate for shovelnose sturgeon and northern pike (Table 10-67). Goldeye were the dominant species, making up 65.9% of the total (Table 10-72). Sauger accounted for 10.6% of the total catch, the highest percentage for all sections.

iii. Results - Electrofishing

a) Spring 1973

Electrofishing with a mobile electrode during spring of 1973 near Armells Creek produced the same species as did the gill nets; however, the relative abundance of species in the catch was different. Snorthead redhorse dominated the spring electrofishing catch, contributing 27.1% as compared to 2.1% for spring gill net catches (Table 10-66).

b) Fall 1973

During the fall of 1973, both mobile and fixed electrode electrofishing units were tested, and the fixed electrode units were found to be much more effective. Nine hundred forty-four fish of 16 species were captured during five experimental electrofishing runs of various lengths.

Table 10-67

Summary of Gill Net Samples from the Lower Yellowstone River
(Fall 1973)
Expressed as Number of Fish per Net Set

Species	Hysham Section	Forsyth Section	Miles City Section	Terry Section	Intake Section
Shovelnose sturgeon	0.00	0.00	0.00	0.17	0.82
Goldeye	41.86	19.17	29.12	49.67	19.18
Rainbow trout	0.00	0.00	0.00	0.17	0.00
Northern pike	0.00	0.04	0.06	0.00	0.36
Carp	0.87	1.21	0.52	0.33	0.45
Goldfish	0.00	0.00	0.03	0.00	0.00
Flathead chub	0.07	0.62	0.24	0.17	0.09
River carpsucker	3.53	3.25	2.03	3.83	2.18
Smallmouth buffalo	0.33	0.38	0.06	0.00	0.00
Shorthead redhorse	1.67	2.08	0.48	0.50	0.00
Longnose sucker	0.53	0.50	0.33	0.17	0.09
White sucker	0.40	0.38	0.18	0.67	0.09
Black bullhead	0.00	0.04	0.00	0.00	0.00
Channel catfish	7.13	5.00	3.70	1.33	2.36
Stonecat	0.20	0.17	0.06	0.00	0.18
Burbot	0.00	0.04	0.00	0.00	0.09
Smallmouth bass	0.00	0.00	0.03	0.00	0.00
White crappie	0.13	0.00	0.09	0.33	0.00
Black crappie	0.00	0.25	0.00	0.17	0.00

Table 10-67
(cont.)

Species	Hysham Section	Forsyth Section	Miles City Section	Terry Section	Intake Section
Yellow perch	0.00	0.21	0.00	0.00	0.00
Sauger	1.13	2.04	1.45	3.83	3.09
Walleye	0.13	0.00	0.00	0.17	0.09
Freshwater drum	0.00	0.00	0.09	0.00	0.00
Total	57.98	35.38	38.47	61.51	29.07

TABLE 10-68

AVERAGE LENGTHS, WEIGHTS AND PERCENTAGES OF TOTAL CATCH FROM 15 GILL NETS FROM THE LOWER YELLOWSTONE RIVER, HYSHAM SECTION, FALL 1973

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Goldeye	628	72.2	12.2	9.4-14.9	0.6	0.2-0.9
Carp	13	1.5	15.6	12.2-21.2	1.7	0.9-3.2
Flathead chub	1	.1	7.5	(only 1 taken)	0.1	(only 1 taken)
River carpsucker	53	6.1	13.9	12.1-15.5	1.1	0.9-1.8
Smallmouth buffalo	5	.6	20.9	18.5-23.2	5.1	3.4-6.0
Shorthead redhorse	25	2.9	12.7	9.1-17.6	1.0	0.3-2.2
Longnose sucker	8	.9	12.5	8.1-17.0	0.9	0.2-1.9
White sucker	6	.7	10.0	7.5-12.2	0.4	0.1-0.8
Channel catfish	107	12.3	17.3	11.6-23.5	1.7	0.5-4.5
Stonecat	3	.3	6.9	5.3- 8.1	0.2	0.2-0.3
White crappie	2	.2	7.9	.9- 8.9	0.3	0.3-0.4
Sauger	17	2.0	14.9	13.2-17.2	1.0	0.7-1.4
Walleye	2	.2	18.4	17.0-19.8	2.1	1.8-2.4
TOTAL	870					

TABLE 10-69

AVERAGE LENGTHS, WEIGHTS AND PERCENTAGES OF TOTAL CATCH FROM 24 GILL NETS FROM THE LOWER YELLOWSTONE RIVER, FORSYTH SECTION, FALL 1973.

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Goldeye	460	54.2	12.3	8.1-14.6	0.6	0.1-1.3
Northern pike	1	Tr[1]	27.7	(only 1 taken)	5.5	(only 1 taken)
Carp	29	3.4	15.6	11.1-23.7	2.1	0.7-6.3
Flathead chub	15	1.8	7.9	4.2- 9.1	0.2	0.1-0.3
River carpsucker	78	9.2	14.1	7.9-18.8	1.3	0.2-2.1
Smallmouth buffalo	9	1.1	21.5	18.2-23.0	5.5	3.1-7.0
Shorthead redhorse	50	5.9	11.8	6.0-20.6	0.9	0.1-3.8
Longnose sucker	12	1.4	11.1	7.0-13.3	0.6	0.1-0.9
White sucker	9	1.1	13.2	10.5-16.8	1.0	0.4-2.1
Black bullhead	1	Tr[1]	8.2	(only 1 taken)	0.2	(only 1 taken)
Channel catfish	120	14.1	17.4	11.0-25.0	1.9	0.3-6.5
Stonecat	4	.5	5.8	5.7- 5.8	0.3	0.2-0.3
Burbot	1	Tr[1]	15.5	(only 1 taken)	0.7	(only 1 taken)
Black crappie	6	.07	6.7	4.8- 7.7	0.2	0.2-0.3
Yellow perch	5	.6	7.1	5.6- 8.3	0.2	0.1-0.2
Sauger	49	5.8	15.4	10.3-21.4	1.3	0.4-3.8
TOTAL	849					

[1] Trace

TABLE 10-70

AVERAGE LENGTHS, WEIGHTS AND PERCENTAGES OF TOTAL CATCH FROM 33 GILL NETS FROM THE LOWER YELLOWSTONE RIVER, MILES CITY SECTION, FALL 1973.

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Goldeye	961	75.7	11.4	7.7-14.2	0.5	0.2-0.9
Northern pike	2	Tr[1]	27.0	25.5-28.5	5.2	4.3-6.0
Carp	17	1.3	16.2	11.0-21.5	2.1	0.6-4.7
Goldfish	1	Tr[1]	9.9	(only 1 taken)	0.6	(only 1 taken)
Flathead chub	8	0.7	7.9	7.1- 9.3	0.2	0.1-0.3
River carpsucker	67	5.3	11.8	7.2-16.0	0.8	0.2-1.7
Smallmouth buffalo	2	Tr[1]	27.2	27.0-27.3	12.0	12.0-12.0
Shorthead redhorse	16	1.3	13.0	8.8-16.7	1.1	0.3-2.2
Longnose sucker	11	1.0	13.6	12.4-14.7	1.1	0.8-1.3
White sucker	6	0.5	11.5	9.3-13.3	0.6	0.3-1.0
Channel catfish	122	9.6	16.3	9.9-28.0	1.5	0.2-6.5
Stonecat	2	Tr[1]	8.0	7.1- 818	0.2	0.1-0.2
Smallmouth Bass	1	Tr[1]	12.8	(only 1 taken)	1.2	(only 1 taken)
White crappie	3	Tr[1]	5.9	5.7- 6.1	0.1	0.1-0.1
Sauger	48	3.8	13.0	8.1-19.7	0.7	0.2-2.4
Freshwater drum	3	Tr[1]	12.1	11.8-12.4	.8	0.8-0.9
TOTAL	1270					

[1] Trace

TABLE 10-71

AVERAGE LENGTHS, WEIGHTS AND PERCENTAGES OF TOTAL CATCH FROM 6 GILL NETS FROM THE YELLOWSTONE RIVER, TERRY SECTION, FALL 1973

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Shovelnose sturgeon	1	.3	13.5	(only 1 taken)	0.4	(only 1 taken)
Goldeye	298	80.8	10.9	8.0-13.9	0.5	0.1-1.0
Rainbow trout	1	.3	18.2	(only 1 taken)	1.53	(only 1 taken)
Carp	2	.6	16.1	10.1-22.0	2.6	0.5-4.7
Flathead chub	1	.3	9.1	(only 1 taken)	0.2	(only 1 taken)
River carpsucker	23	6.2	11.9	6.1-17.4	0.9	0.1-2.3
Shorthead redhorse	3	.8	11.3	6.0-16.2	0.7	0.1-1.3
Longnose sucker	1	.3	14.6	(only 1 taken)	0.6	(only 1 taken)
White sucker	4	1.1	14.1	12.5-15.2	1.1	0.8-1.3
Channel catfish	8	2.1	16.1	8.8-19.3	1.5	0.2-2.7
White crappie	2	.6	5.7	5.2- 6.3	0.1	0.1-0.1
Black crappie	1	.3	6.2	(only 1 taken)	0.1	(only 1 taken)
Sauger	23	6.2	12.8	9.0-19.4	0.7	0.2-2.5
Walleye	1	.3	16.8	(only 1 taken)	1.5	(only 1 taken)
TOTAL	369					

TABLE 10-72

AVERAGE LENGTHS, WEIGHTS AND PERCENTAGES OF TOTAL CATCH FROM 11 GILL NETS FROM THE YELLOWSTONE RIVER, INTAKE SECTION, FALL 1973

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Shovelnose sturgeon	9	2.8	22.4	13.5-27.0	1.1	0.2-1.9
Goldeye	211	65.9	10.8	6.0-14.2	0.5	0.2-1.12
Northern pike	4	1.3	25.8	20.0-31.1	4.2	2.2-7.5
Carp	5	1.6	15.0	11.0-18.4	1.7	0.6-3.0
Flathead chub	1	0.3	8.1	(only 1 taken)	0.2	(only 1 taken)
River carpsucker	24	7.5	13.6	8.7-18.2	1.3	0.4-3.4
Longnose sucker	1	0.3	13.6	(only 1 taken)	1.0	(only 1 taken)
White sucker	1	0.3	13.5	(only 1 taken)	1.1	(only 1 taken)
Channel catfish	26	8.1	17.4	9.1-24.2	1.9	0.2-4.4
Stonecat	2	.6	7.7	7.1- 8.2	.2	.2- .2
Burbot	1	0.3	14.9	(only 1 taken)	0.6	(only 1 taken)
Sauger	34	10.6	13.3	7.9-21.0	0.8	0.1-3.2
Walleye	1	0.3	14.6	(only 1 taken)	0.9	(only 1 taken)
TOTAL	320					

Goldeye and shorthead redhorse were the predominant species, constituting 25.3% and 24.1%, respectively, of the total catch, as compared to 69.5% for goldeye and 2.6% for shorthead redhorse in fall gill net samples. This illustrates the selectivity of various sampling methods and the difficulty in sampling all species effectively. Therefore, the relative abundance of certain species presented in the catch statistics may not accurately reflect their relative abundance in the river.

c) Spring 1974

Spring sampling in 1974 was conducted in an attempt to obtain estimates of population structure, numbers and biomass for as many species as possible in three 1-mile sections of river near Forsyth (Figure 10-42). Section A began two river miles above the MPC intake structure and ended one river mile above that point. Section C began at the intake structure and ended one river mile below it. Section E began at the Rosebud diversion dam at Forsyth and extended on mile downstream.

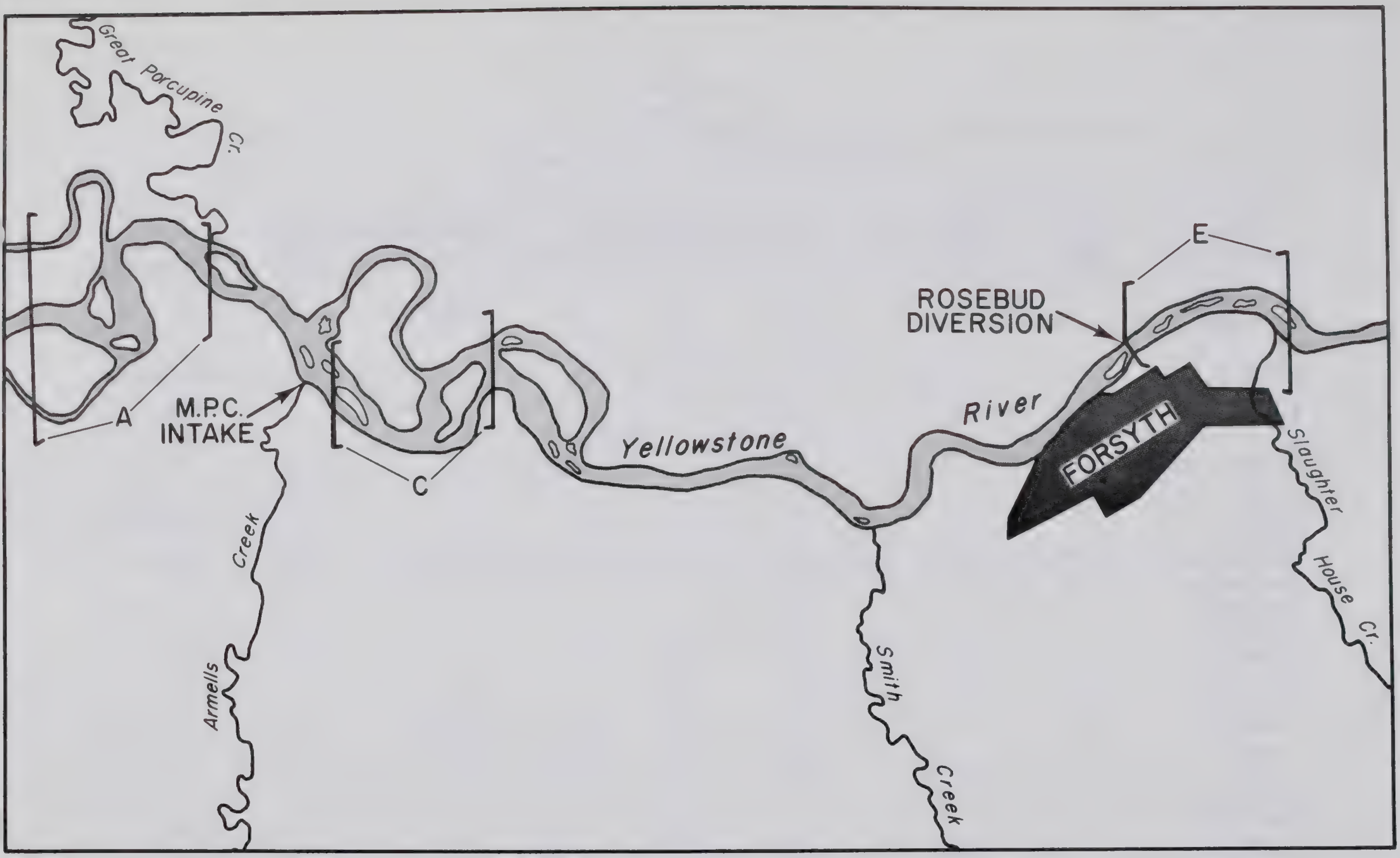
Total numbers of sampling runs were 3, 6 and 17 for Sections A, C and E, respectively. All species were collected in all runs in Sections A and C. All species were collected on three runs in Section E, while sport fish only were collected during the final 14 runs.

The total catch for all three sections was 4,698 fish of 19 species. Goldeye dominated the catch, accounting for 55.4% of the total. Carp, river carpsuckers, shorthead redhorse, and longnose sucker made up 17.9%, the catch, respectively (Table 10-73).

The sauger and walleye spawning run, which occurs at the Rosebud diversion (Section E), was monitored from April 5 to May 20, 1974. Lengths, weights and sexes were determined, and numbered floy anchor tags were attached before the fish were released. Other important sport fish were also taken coincidental to sauger and walleye sampling and handled in the same manner. Four hundred thirty fish, including 301 sauger and 13 walleye, were marked and released (Table 10-74).

Mean lengths and weights for 310 sauger (taken in Section A and C) were 15.4 inches and 1.2 pounds, respectively, ranging from 6.6 inches and 0.1 pounds to 26.8 inches and 6.5 pounds. The largest sauger may have been a sauger walleye hybrid. Sauger taken in Section E averaged larger than those taken in fall gill net samples, which averaged 13.9 inches and 0.9 pound and ranged from 7.9 to 21.4 inches and 0.1 to 3.8 pounds. The large size of fish taken during the spring sampling period is indicative of a spawning run composed primarily of larger, mature fish. Spawning runs of sauger and walleye in rivers have been documented by a number of other workers including Morris (1965), Johnson and Johnson (1971), Madsen (1971), Crowe (1954), Schumacher (1965), and Olsen and Scidmore (1962).

Nineteen of the 295 sauger marked were recaptured, providing a 6.4% return of marked sauger (Table 10-75). The Schnabel estimator was used to estimate sauger numbers in the run during the sampling period. Other sport fish in Section E were not taken in large enough numbers to estimate. Since the sauger estimate was made on a



YELLOWSTONE RIVER NEAR FORSYTH ILLUSTRATING FISH STUDY SECTIONS IN RELATION TO THE MONTANA POWER COMPANY WATER INTAKE STRUCTURE

Figure 10-42

Table 10-73

Species Composition and Relative Abundance of Electrofishing Catch, Spring 1974, On Runs Where All Fish Were Sampled

Species	Sec. A. (3)*		Sec. C (6)*		Sec. E (3)*		Species Total	Percentage of Grand Total (12)*
	No. Fish	Percentage of Total	No. Fish	Percentage of Total	No. Fish	Percentage of Total		
Shovelnose sturgeon	0	0	0	0	3	Tr[1]	3	Tr[1]
Goldeye	1,387	71.8	490	44.8	727	43.5	2,604	55.4
Brown trout	0	0	1	Tr[1]	0	0	1	Tr[1]
Northern pike	0	0	0	0	1	Tr[1]	1	Tr[1]
Carp	218	11.3	223	20.4	402	24.1	843	17.9
River carpsucker	249	12.9	234	21.4	325	19.5	808	17.2
Blue sucker	0	0	0	0	1	Tr[1]	1	Tr[1]
Smallmouth buffalo	8	Tr[1]	19	1.7	2	Tr[1]	29	Tr[1]
Bigmouth buffalo	16	Tr[1]	11	1.0	1	Tr[1]	28	Tr[1]
Shorthead redhorse	24	1.2	43	3.9	115	6.9	182	3.9
Longnose sucker	6	Tr[1]	38	3.5	29	1.7	73	1.6
White sucker	13	Tr[1]	17	1.6	16	Tr[1]	46	1.0
Mountain sucker	0	0	1	Tr[1]	0	0	1	Tr[1]
Channel catfish	6	Tr[1]	8	Tr[1]	8	Tr[1]	22	Tr[1]
Burbot	0	0	3	Tr[1]	14	Tr[1]	17	Tr[1]
Green sunfish	0	0	1	Tr[1]	0	0	1	Tr[1]

Table 10-73
(cont.)

Species	Sec. A. (3)* No. Fish	Sec. A. (3)* Percentage of Total	Sec. C (6)* No. Fish	Sec. C (6)* Percentage of Total	Sec. E. (3)* No. Fish	Sec. E. (3)* Percentage of Total	Species Total	Percentage of Grand Total (12)*
Sauger	5	Tr[1]	4	Tr[1]	20	1.2	29	Tr[1]
Walleye	0	0	0	0	6	Tr[1]	6	Tr[1]
Freshwater drum	1	Tr[1]	1	Tr[1]	1	Tr[1]	3	Tr[1]
Total	1,933		1,094		1,671		4,698	

* Number of runs

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[1] Trace

TOTAL 10-74

COMPOSITION AND AVERAGE LENGTHS AND WEIGHTS OF ELECTROFISHING CATCH, SECTION E ON RUNS WHERE ONLY SPORT SPECIES WERE TAKEN.

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Shovelnose sturgeon	6	1	32.4	29.0-39.0	4.9	2.8-6.5
Northern pike	1	Tr[1]	24.5	(only 1 taken)	4.4	(only 1 taken)
Channel Catfish	42	10	19.7	13.1-29.0	3.6	.62-11.8
Burbot	53	12	13.7	6.7-20.7	0.6	0.1-2.6
Drum	14	3	15.8	14.5-18.9	1.8	1.3-3.7
Sauger	301	70	15.4	6.6-26.8	1.2	0.1-6.5*
Walleye	13	3	19.8	18.6-23.0	2.8	2.0-4.3

*Includes possible sauger - walleye hybrid

[1] Trace

spawning run and new fish were continually entering the area, several conditions which Chapman and Overton (1966) believe necessary to make a valid estimate using the Schnabel estimator were not met. Ricker (1958), however, has said that the estimator can still be useful although some conditions are not met.

It was estimated that 2,024 sauger were present in Section E during the sampling period. Confidence intervals (Chapman and Overton 1966) at the 80% level were 1,564 to 2,867. While this estimate cannot be considered accurate, it is probably indicative of the magnitude of the sauger numbers present.

TABLE 10-75

Number of Sauger Marked Per Run, Marked at Large and Recaptured in Section E.

Date	Number Marked Per Run	Total Marked at Large	Number of Recaptures
4/5/74	0	0	0
4/18/74	7	7	0
4/23/74	13	20	0
4/25/74	1	21	0
4/29/74	30	51	1
4/30/74	3	54	0
5/2/74	3	57	0
5/7/74	54	111	2
5/8/74	32	143	3
5/9/74	30	173	2
5/13/74	44	217	4
5/14/74	16	233	4
5/16/74	29	262	1
5/20/74	33	295	2
Total	295		19

Sauger and walleye were apparently spawning in Section E during the sampling period. The first ripe male sauger and ripe female walleye were taken during the last week of April. Ripe female sauger were not taken until the second week of May. A spent female sauger was taken on May 20 along with several spent female walleyes.

Water temperatures ranged from 42°F to 61°F during the sampling period. Based on recaptured spent females (walleye and sauger), some spawning was known to have occurred between May 16 and 20, when water temperatures were 45°F to 52°F. Morris (1964) reported that sauger had not spawned in the Missouri River in Nebraska when water temperatures were 47°F.

Ripe sauger and walleye were commonly taken in water one to four feet deep, with a sand or gravel bottom and a moderate current. Scott and Crossman (1973) reported similar spawning sites for the two species. Johnson (1961) reported walleye spawning areas in a tributary of Lake Winnibigoshish as having gravel to sand bottom with water depths of 15 to 24 inches. He reported that they also preferred such areas in streams and lakes.

Eight (2.7%) of the 295 tagged sauger were returned by anglers. Five fish were taken in the area where they were tagged, and three exhibited movement. Two fish, tagged on May 8 and 20, were caught at the Myers diversion on July 26, after an upstream movement of approximately 30 miles. Another sauger tagged April 17 was caught at the mouth of the Tongue River on April 22, having moved approximately 55 miles downstream in five days.

iv. Other Notable Species

a) Burbot

Burbot are also an important sport fish in the lower river. They are commonly fished for at night in the mouths of small creeks or below diversion sturctures. Angling at night during March and April is probably the most effective method for sampling burbot at present. Three anglers using large minnows for bait in Section E caught 36 burbot in four hours (11:00 p.m. to 3:00 a.m.) in early April. Average length and weight for those fish were 15.1 inches and 0.63 pound.

A total of 53 burbot were taken by electrofishing in Section E and averaged 13.7 inches and .64 pound (Table 10-74). Many were observed while electrofishing, but few were captured.

Burbot reportedly prefer areas with sufficient shelter in which to hide, such as areas of large rocks (Robins and Deubler 1955). Water temperatures higher than 70°F are tolerated only for short periods of time (Miller 1970). McCrimmon (1959) found that fish in Lake Simcoe, Ontario, spawned over gravely shoals at a depth of 3 to 15 feet. They usually spawn under the ice in early February at 33°F to 35°F (Scott and Crossman 1973).

b) Channel Catfish

Channel catfish are sought by many anglers in the lower river, and, based on warden creel checks, make up about 25% of the fishermen's catch. Gill netting proved the most effective method of capture, and 383 were taken in fall gill net samples. Gill net catch rates for catfish generally decreased downstream (Table 10-67). This may be attributed to the smaller number of backwater areas in the downstream sections. Large numbers were observed in backwater areas in late August. These may be the only areas which reach temperatures suitable for spawning and which provide adequate cover the nest sites. Other studies show that spawning generally takes place in secluded places under rocks and logs or in animal burrows or other protected sites (Morris, Morris and Witt 1972). Van Eeckhout (1974) reported spawning in the Little Missouri River in North Dakota from mid-June to late July at temperatures between 70°F and 80°F.

c) Shovelnose Sturgeon

Shovelnose sturgeon are commonly caught by anglers in the river downstream from Forsyth. None were taken above the Rosebud diversion. Residents of Hysham state that none have been caught in that area recently, but that at one time they were quite common. The construction of diversion structures, such as the one at Forsyth, may have formed a barrier to their upstream movements.

A total of 50 shovelnose sturgeon were taken during the spring in Section E. Six were taken by electrofishing and 44 by drifting large mesh gill nets through deep, swift runs. Average length and weight for these 50 fish were 33.5 inches and 6.2 pounds, with a range of 29.5 to 36.5 inches and 3.86 to 9.00 pounds. Ten other shovelnose sturgeon taken in fall gill net samples at Terry and Intake had an average length of 17.3 inches and an average weight of 0.69 pounds, which was considerably smaller than those taken at Forsyth. Larger fish at Forsyth suggests that the samples were from a spawning run.

Gould and Schmalback (1973) reported the preferred habitat to be sandbars with relatively high velocities for fish in the Missouri River below Gavins Point Dam. Helms (1973) collected young-of-the-year in similar areas of the Mississippi in Iowa.

d) Northern Pike

Northern pike are frequently caught by anglers in the lower river, usually in the mouths of tributaries or below diversion structures. Interviews with anglers indicate the species is commonly taken at the mouths of Big Porcupine and Rosebud Creeks, below the Rosebud diversion structure near Forsyth, in the mouth of the Tongue River, below the Intake diversion near Glendive, and at the mouth of Hay Creek near Sidney. Only eight were taken during all sampling, but several were observed while electrofishing in Section E.

Northern pike are spring spawners, and spawning takes place at temperatures between 40°F and 50°F soon after the ice goes out over areas of flooded vegetation which are essential to survival of young (Schultz 1955). Areas meeting these requirements occur infrequently in some backwaters and the lower portions of some tributaries.

e) Paddlefish

Paddlefish, probably the most popular sport fish in the lower river, occur only seasonally. Large numbers are taken by snaggers each year at the Intake diversion dam just downstream from Glendive. In some years they are also caught below the Rosebud diversion at Forsyth and at the mouths of the Tongue and Powder Rivers.

Investigations of paddlefish spawning runs at Intake have yielded considerable data relating to numbers of fish in the run, structure of the population, and angler harvest. A total of 2,928 paddlefish has been tagged at Intake since 1964. To date, at least 10.1% of these tagged fish have been recaptured and reported. The majority (91.9%) of those recaptured were taken in the same area where they were tagged, but 24 fish tagged at Intake were caught in other areas. Twelve tagged fish were recaptured in Garrison Reservoir, approximately 200 miles downstream in North Dakota. Tagged fish have also been caught near Terry, at the mouth of the Tongue River, at Forsyth, and in the dredge cuts below Fort Peck Dam on the Missouri River (Elser (1974a).

During the 1973 run, an estimate of the number of fish was made using the Schnabel method. The run was estimated to contain between 11,120 and 25,266 paddlefish (95% confidence limits). A creel census at Intake during the 1973 season resulted in an estimate of 2,449 anglers fishing 10,146 hours and snagging 4,670 paddlefish. The average number of anglers per day was 31 during the week and 45 on weekends. The total weight of the 1973 catch was 77 tons (Elser 1974a).

Little is known about the spawning habits of paddlefish. A literature review indicates they apparently spawn over gravel in swift water at depths of 20 feet during high water in May to June (Purkett 1961). Spawning sites in the Yellowstone River are still unknown.

f) Goldeye

Four hundred ninety were marked in Section C, eight of which were recaptured. While this is a very low return rate, an estimate of population strength was computed. Based on the Schnabel estimator, the total goldeye population was 9,170 per mile of river. Confidence intervals at the 80% level were 5,929 to 20,229, because of the low recapture rate. While this estimate cannot be considered reliable (due to wide confidence bands), it is indicative of the size of the goldeye population in the river and demonstrates the difficulties of marking enough fish for accurate population estimates.

g) Additional Nongame Species

It was likewise difficult to obtain an adequate sample size of other species. Returns for carp (10 of 223 marked) and river carpsucker (8 of 234 marked) were also very low. Estimated numbers per mile were 1,737 for carp (with 80% confidence intervals of 1,149 to 3,562) and 2,578 for river carpsucker (with 80% confidence intervals of 1,596 to 6,695). These estimates cannot be considered accurate, but indicate the tremendous productivity of the river.

v. Fish as a Resource

These species and other nongame fish are apparently abundant in the lower Yellowstone and are readily caught but not actively sought by anglers. Although they are not important as a sport fishery, they do represent a valuable resource. Based on current population estimates for the United States, the demand for edible fish will reach 2.5 billion pounds per year by 1980 as compared to 1.9 billion pounds for 1960 (Barth 1969). With future increases in world population, utilization of these available protein sources may be necessary.

Interest has recently been shown in the commercial harvest of goldeye from the lower river. A market is presently available for Montana goldeye in Canada, and commercial utilization of this species from the Yellowstone in the near future is probable, since the current wholesale price for this species is approximately 20 cents per pound.

The most relevant point to be emphasized concerning these species at this time is that this abundant biomass is a clear indication of the great productivity of this natural river system.

d. Annotated List and Distribution of Species

A discussion of the 13 familes and 49 species of fish present in the Yellowstone River follows. The probable distribution of 33 of the 49 species is illustrated in Figure 10-43.

i. Sturgeon Family (Acipenseridae)

a) Pallid Sturgeon (Scaphirhynchus albus) are considered rare, with a few specimens being verified from the lower Yellowstone each year. Very little is known about the distribution or life history of this species.

b) Shovelnose sturgeon (Scaphirhynchus platorynchus) are common in the lower Yellowstone and found at least as far upstream as the Rosebud diversion structure at Forsyth. They are commonly taken by fishermen at the mouths of the Tongue and Powder Rivers and below the intake diversion.

ii. Paddlefish Family (Polyodontidae)

a) Paddlefish (Polyodon spathula) are common in the lower river during their spawning migration. They are also taken in some years at the mouth of the Tongue River and below the Rosebud diversion at Forsyth. Reports indicate that at times they move upstreat at least as far as the mouth of the Bighorn River.

iii. Mooneye Family (Hiodontidae)

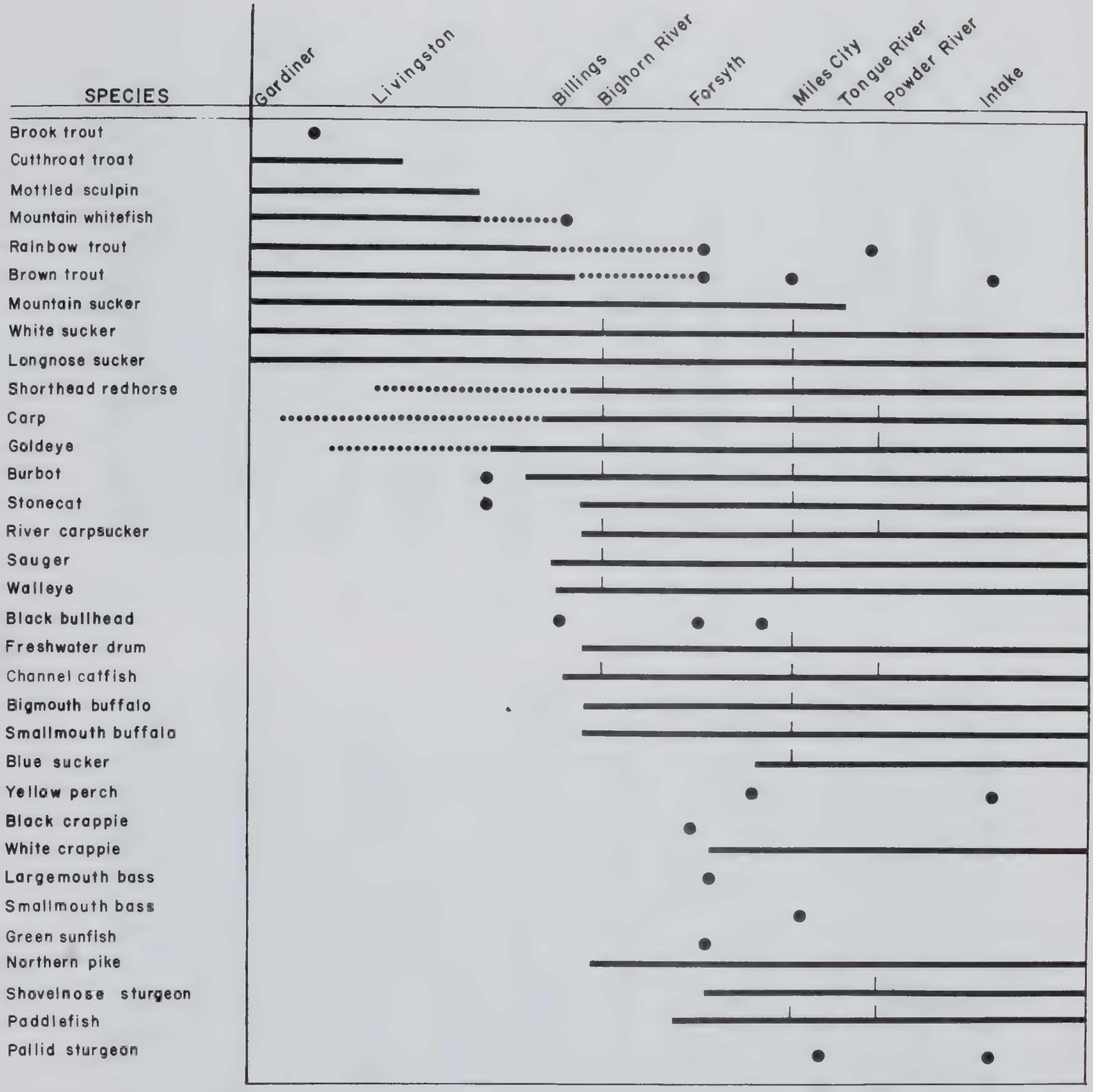
a) Goldeye (Hiodon alsoides) are abundant in the lower Yellowstone from Billings downstream and have been taken as far upstream as Pine Creek above Livingston (Brown 1971c).

iv. Trout Family (Sal monidae)

a) Mountain whitefish (Prosopium williamsoni) are abundant in the upper river and are taken infrequently as far downstream as Billings.

b) Cutthroat trout (Salmo clarki), the native trout of the Yellowstone, occur in the upper river betwen Gardiner and Livingston, but are much less abundant than the brown or rainbow. They are not found much farther downstream than Big Timber.

c) Rainbow trout (Salmo gairdneri) are abundant from Gardiner to Billings. They have been taken on rare occasions as far downstream as Forsyth, and one was taken near Terry.



LONGITUDINAL DISTRIBUTIONS OF SOME FISHES OF THE YELLOWSTONE RIVER OF MONTANA

Broken lines denote rare or occasional occurence; wide line indicates reproductive success in the area; dots indicate occurrence of a single or a few individuals; vertical lines indicate occurrence in tributaries.

FIGURE 10-43

d) Brown trout (Salmo trutta), abundant in the upper and middle river from Gardiner to Billings, are rare downstream. A few have been taken as far downstream as Intake.

e) Brook trout (Salvelinus fontinalis) are rare in the upper Yellowstone, and no self-sustaining populations are believed to exist in the mainstem (Peterman 1974).

v. Pike Family (Esocidae)

a) Northern pike (Esox lucius) are found in the lower river and have been collected near Forsyth, Miles City, and Intake. They are reportedly taken by anglers as far upstream as the mouth of the Bighorn River.

vi. Minnow Family (Cyprinidae)

a) Carp (Cyprinus carpio) are abundant in the lower river, but present only in very limited numbers in the upper river.

b) One goldfish (Carassius auratus) was taken in the lower river at Miles City.

c) Golden shiner (Notemigonus crysoleucas) have been recorded only for the lower river.

d) Pearl dace (Semotilus margarita) have been recorded only for the lower river.

e) Creek chub (Semotilas atromaculatus) have been recorded only for the lower river.

f) Flathead chub (Hybopsis gracilis) are found in the middle and lower portions.

g) Sturgeon chub (Hybopsis gelida) have been recorded only for the lower river.

h) Lake chub (Couesius plumbeus) are found primarily in the lower river; however, one specimen has been recorded near Livingston.

i) Emerald shiner (Notropis atherinoides) have been recorded only for the lower river.

j) Sand skiner (Notropis stramineus) have been recorded only for the lower river.

k) Brassy minnow (Hybognathus hankinsoni) have been recorded only for the lower river.

l) Plains minnow (Hybognathus placitus) have been recorded only for the lower river.

m) Silvery minnow (Hybognathus nuchalis) are found in the middle and lower portions.

n) Fathead minnow (Pimephales promelas) have been recorded only for the lower river.

o) Longnose dace (Rhinichthys cataractae) are present the entire length of the river in Montana.

vii. Sucker Family (Catostomidae)

a) River carpsucker (Carpoides carpio) are abundant in the lower river and have been reported as far upstream as Laurel.

b) Blue sucker (Cycleptus elongatus) is present in the lower Yellowstone from Forsyth downstream.

c) Smallmouth buffalo (*Ictiobus bubalus*) are present in the lower river and have been taken from the vicinity of Hysham and downstream.

d) Bigmouth buffalo (*Ictiobus cyprinellus*) occur in the lower river and have been taken from the vicinity of Hysham and downstream. Possible hybrid bigmouth × smallmouth buffalo have been taken near Forsyth.

e) Shorthead redhorse (*Moxostoma macrolepidotum*) have been reported for the entire river. They are uncommon in the upper river, but abundant in the lower river.

f) Longnose sucker (*Catostomus catostomus*) are common the entire length of the river.

g) White sucker (*Catostomus commersoni*) are common the entire length of the river.

h) Mountain sucker (*Catostomus platyrhynchus*) are found the entire length of the Yellowstone.

viii. Catfish Family (Ictaluridae)

a) Black bullhead (*Ictalurus melas*) appear to be locally common in the lower river. Specimens have been taken in the vicinity of Laurel and near Forsyth.

b) Channel catfish (*Ictalurus punctatus*) are abundant in the lower river below the Huntley project diversion near Billings.

c) Stonecat (*Noturus flavus*) have been collected from Reed Point downstream and are common in the lower river.

ix. Codfish Family (Gadidae)

a) Burbot (*Lota lota*) have been taken from Reed Point downstream and are common in the lower river.

x. Sunfish Family (Centrarchidae)

a) A single green sunfish (*Lepomis cyanellus*) was collected near Forsyth.

b) The pumpkinseed (*Lepomis gibbosus*) has been recorded in the lower Yellowstone.

c) The bluegill (*Lepomis macrochirus*) is generally found in ponds and lakes but is known to occur in the Yellowstone River.

d) One smallmouth bass (*Micropterus dolomieui*) was taken near Miles City.

e) A largemouth bass (*Micropterus salmoides*) was collected near Forsyth.

f) White crappie (*Pomoxis annularis*) appear to be locally common in the mouths of small streams and in large backwaters of the lower river below Hysham.

g) Black crappie (*Pomoxis nigromaculatus*) were collected near Forsyth.

xi. Perch Family (Percidae)

a) Yellow perch (Perca flavescens) are present in the lower river. A few specimens have been taken in the vicinity of Forsyth.

b) Sauger (Stizostedion canadense) are common in the entire lower river below Billings.

c) Walleye (Stizostedion vitreum) are present but uncommon in the lower river below Billings, and specimens have been taken near Hysham, Forsyth, Miles City, Terry and Intake. One possible walleye*sauger hyrid was taken near Forsyth.

xii. Orum Family (Sciaenidae)

a) Freshwater drum (Aplodinotus grunniens) are found in the lower Yellowstone from Billings downstream.

xiii. Sculpin Family (Cottidae)

a) Mottled sculpin (Cottus bairdi) are confined to the upper and middle portions.

2. Aquatic Vertebrates Other Than Fish

Information on vertebrates other than fish was obtained incidental to fisheries work. Turtles were collected while sampling fish, and observations were made of some amphibians. Three species of turtle were collected in the lower Yellowstone, including the common snapping turtle (Chelydra serpentina), the western spiny soft-shelled turtle (Trionyx spiniferus hartwegi), and the western painted turtle (Chrysemys picta aelli). The three amphibians observed in or near the Yellowstone River were the toad (Bufo spp.), the tiger salamander (Ambystoma tigrinum), and the leopard from (Rana pipiens).

3. Benthic Macroinvertebrates

a. Discussion

Benthic organisms are comprised primarily of immature insects, but other invertebrate groups are represented. They are particularly suitable in monitoring changes in the aquatic environment, because their habitat preference and low mobility cause them to directly affected by any alteration (Wilhm 1970). Considerable importance has been placed on certain groups as indicators of the condition of a particular lotic environment. Stoneflies (Plecoptera), mayflies (Ephemeroptera), and caddisflies (Trichoptera) are usually considered residents of a healthy environment, whereas certain types of true flies (Diptera) and segmented worms (Annelida) are considered characteristic of a disturbed environment.

Benthic organisms live in or on the substratum of a river. The primary areas of their occurrence and production are riffle areas, where velocities are sufficient to keep gravel and rubble substrate free from sediment. The undersides of rocks and the attached algae provide shelter. Most of these organisms require the movement of water over their bodies to aid in respiration and to bring food (Hynes 1970). The riffles are areas of primary production in fast flowing rivers.

In such rivers as the Yellowstone, the periphyton consisting chiefly of algae occupy a position of importance similar to the phytoplankton of lakes, and the associated macroinvertebrates assume a position similar to the zooplankton (Smith 1966). The macroinvertebrates are of extreme importance to the fish fauna of a river. Many fish species feed upon them exclusively, while the young of other species are dependent upon them to varying degrees.

Limited work has been done on the benthic macroinvertebrates of the Yellowstone. Stadnyk (1971) identified 25 species of stoneflies in the Yellowstone from near Gardiner to Laurel. He found that the number of species decreased downstream, with 17 species being identified near Gardiner and 12 near Laurel.

b. Sampling

Two methods were used in the collection of benthic organisms: 1) a Needham screen with a metal frame to delineate the area of substrate sampled, and 2) a Waters Round one-square-foot sampler. For quantitative sampling the Waters type is superior (Waters and Knapp 1966).

Benthic macroinvertebrate sampling in the vicinity of Armells Creek was conducted during spring 1973. Four 10-square-foot samples were taken with a Needham screen. Two samples were taken in March and two in May (Table 10-76). Samples taken during May had significantly fewer organisms than those taken in March; however, areas sampled in May may have been under water for only a short time, due to increased discharge.

During the fall of 1973 and spring of 1974, benthos samples were taken at eight sites on the lower and middle river. A Waters Round one-square-foot bottom sampler was used and four samples taken at each site (Table 10- 77). Although samples from all locations exhibited a diverse bottom fauna, only the Laurel site had all six orders. Trichoptera was notably absent from two sites, below Billings and Hysham. The samples from near Armells Creek, when compared to those of the previous spring, are comparable in total numbers, but the composition of the samples differs considerably. Differences in these samples may be due to differences in the two sampling methods, or possibly to a difference in the substrate of the areas sampled.

4. Plankton

Plankton samples from the Yellowstone River were taken near the mouth of Armells Creek in the spring of 1973 and from near Custer and Myers in the spring of 1974. Samples were taken by suspending an 18-inch square .046-inch mesh plankton net in the current for five minutes.

The sample from near Armells Creek produced 39 species of algae (37 species of diatoms and two species of green algae). Zooplankton also occurred in small numbers (Table 10-78).

The sample from near Custer produced 48 species and varieties of diatoms, four genera of green algae, one genus of red algae and two genera of blue-green algae. The Myers sample contained 54 species and varieties of diatoms, three genera of green algae, one genus of blue-green algae and one genus of red algae (Table 10-

Table 10-76

Average Numbers of Benthic Macroinvertebrates per Square Foot Collected with a Needham Screen.

	March 1973		May 1973	
	Above Armells Cr.	Below Armells Cr.	Above Armells Cr.	Below Armells Cr.
Plecoptera	0.4	3.2	5.8	3.3
Trichoptera	30.4	11.2	8.1	12.6
Ephemeroptera	30.5	200.4	61.3	88.8
Diptera	145.1	94.0	0.5	59.4
Coleoptera	0.0	0.0	0.1	0.1
Annelida	0.2	0.1	0.8	0.3
Total	206.6	308.9	76.6	164.5

TABLE 10-77

Average Numbers of Benthic Macroinvertebrates per Square Foot (collected with a Waters Round Sampler)

Station	Year	PLECOPTERA	TRICHOPTERA	EPHEMEROPTERA	DIPTERA	COLEOPTERA	ANNELIDA	Other	Total
At Laurel	1973	60.0	267.3	461.0	567.0	25.0	3.5	1.3	1385.1
Below Billings Sewage Plant	1973	2.3		231.8	321.0		12.0	1.8	568.9
Below Huntley Bridge	1973	29.5	5.3	313.3	442.8			3.5	794.4
At Hysham Pumphouse	1974	6.5		71.3	5.5				83.3
Above Armells Creek	1973*	34.0	56.3	66.0	104.5				260.8
Below Armells Creek	1974	5.3	1.3	95.0	3.0				104.6
Above Miles City at R. R. Bridge	1973*	16.0	5.3	39.3	12.8				73.4
	1974	22.5	19.5	135.3	88.0			1.8	267.1
Below Miles City at Robert's Island	1973*	15.8	182.5	28.3	57.8				284.4

* Fall sampling - all others collected in April or May

Table 10-78

Flora and Fauna Collected in Plankton Samples from the Yellowstone River near Armells Creek, Spring 1973

DIATOMS (CHRYSOPHYTA)

Navicula viridula
Navicula tripunctata
Navicula symmetrica
Navicula cryptocephala
Navicula cryptocephala var. *veneta*
Navicula salinarum var. *intermedia*
Navicula radiosa var. *tenella*
Navicula lanceolata
Nitzschia amphibia
Nitzschia capitellata
Nitzschia sp.
Nitzschia sublinearis
Nitzschia dissipata
Nitzschia acicularis
Cymbella sinuata
Cymbella ventricosa
Cymbella naviculiformes
Cymbella turgida
Cyclotella sp.
Cocconeis placentula var. *euglypta*
Achnanthes minutissima
Achnanthes lanceolata var. *dubia*
Amphora ovalis var. *pediculus*
Diatoma vulgare
Diatoma tenue
Fragilaria vaucheriae
Fragilaria virescens
Gomphonema constrictum
Gomphonema olivaceum
Hannaea arcus
Stauroneis smithii
Stephanodiscus sp.
Surirella ovalis
Surirella ovata var. *innata*
Surirella ovata var. *pinnata*
Pinnularia brevissonii
Rhoicosphenia curvata

GREEN ALGAE (CHLOROPHYTA)

Scenedesmus sp.
Chlorella sp. (Green coccoids)

MACROINVERTEBRATES

Cinygma sp.
Ameletus sp.
Acanthometropus sp.
Diamesa sp.
Simulud sp.
Isoperla sp.
Hydropsyche sp.
Chaetogaster sp.
Nematoda

ROTIFERS

Keratella cochlearis
Brachionis canciflora
Notholca accuminata

COPEPODS

Copepodids

PROTOZOA

Centropyxis sp.

79). In the Custer and Myers samples, the most abundant algae by volume was Cladophora, a common sessile green algae. However, as a group, the diatoms were the most abundant and diverse. A total of 75 varieties and 23 genera of diatoms, six genera of green algae, two genera of blue-green algae, and one genus of red algae was identified. One species, Fragilaria croto nensis, is truly planktonic. All other taxa are either sessile or quasi-planktonic (Bahls 1974).

In the lower portion of the Yellowstone River, the plankton consist of sessile algae and bottom fauna dislodged from the substrate. They, therefore, are not true plankton, and their area of production is primarily the riffle areas where a suitable clean substrate exists. The lack of true plankton is a common characteristic of cool, fast-flowing rivers (Hynes 1970). Within such rivers, the periphyton is the primary producer and is no less important than true phytoplankton.

10.1.9.2. Lower Yellowstone Tributaries

The three major tributaries of the lower Yellowstone, the Bighorn, Tongue, and Powder Rivers, are under serious consideration for future water development projects related to industrial water uses. These tributaries must be considered important to the entire river system as sources of added flows and as important spawning and rearing areas for certain fish species which move into them from the Yellowstone. Many smaller tributaries may also be important spawning and rearing areas.

A. Bighorn River

With present water releases from Bighorn Reservoir (Yellowtail Dam), a substantial cold water fishery has developed in the portion of the river from the Afterbay Dam to St. Xavier. From St. Xavier to the mouth, a diverse warm water fishery exists. The important species in the upper portion are brown and rainbow trout, while walleye, burbot and channel catfish are important in the lower reaches.

Electrofishing samples were taken in two 5-mile sections of the Bighorn River in October 1973. The upstream section started near the mouth of Soap Creek, and the downstream section began 17 miles below Hardin.

The eight species taken in the upper section were rainbow trout, brown trout, carp, longnose sucker, mountain sucker, shorthead redhorse, flathead chub and burbot. Rainbow trout ranged from 5.9 inches and 0.14 pound to 22.5 inches and 4.55 pounds, with an average length and weight of 11.8 inches and 0.86 pound. Brown trout in this section ranged in length from 6.0 inches to 20.7 inches and in weight from 0.08 pound to 4.30 pounds. The average length and weight for brown trout were 12.6 inches and 1.02 pounds.

Twelve species (goldeye, carp, longnose sucker, mountain sucker, white sucker, shorthead redhorse, river carpsucker, flathead chub, stonecat, channel catfish, burbot, and sauger) were taken in the lower section. The electrofishing catch was dominated by longnose sucker, at 30.1% of the total catch, followed by carp, which made

Table 10-79

Algae Collected in Two Plankton Samples from the Yellowstone River at Myers and Custer, Spring 1974
(Data from Bahls 1974)

DIATOMS (CHRYSOPHYTA)

Achnanthes deflexa
Achnanthes lanceolata
Achnanthes minutissima
Amphora ovalis var. *pediculus*
Biddulphia laevis
Caloneis amphisbaena
Cocconeis pediculus
Cocconeis placentula var. *euglypta*
Cyclotella glomerata
Cymatopleura solea
Cymbella affinis
Cymbella microcephala
Cymbella prostrata
Cymbella sinuata
Cymbella turgida
Cymbella ventricosa
Diatoma anceps
Diatoma tenue
Diatoma vulgare
Diatoma vulgare var. *breve*
Epithemia sorex
Epithemia zebra var. *saxonica*
Fragilaria construens
Fragilaria construens var. *venter*
Fragilaria crotonensis
Fragilaria vaucheriae
Fragilaria vaucheriae var. *novum*
Fragilaria sp.
Gomphoneis herculeana
Gomphoneis sp.
Gomphonema bohemicum
Gomphonema olivaceum
Gomphonema olivaceum var. *calcarea*
Gomphonema parvulum
Gomphonema parvulum var. *micropus*
Gyrosigma obtusatum
Gyrosigma sp.
Hannaea arcus
Mastogloia sp.
Meridion circulare
Navicula anglica var. *subsalsa*
Navicula arvensis
Navicula cryptocephala
Navicula cryptocephala var. *veneta*
Navicula grimmei
Navicula heufleri var. *leptocephala*
Navicula luzonensis
Navicula minima
Navicula muralis
Navicula pelliculosa
Navicula pupula
Navicula tripunctata
Navicula viridula
Navicula viridula var. *avenacea*
Navicula viridula var. *linearis*
Navicula sp.
Nitzschia acuta
Nitzschia capitellata
Nitzschia dissipata
Nitzschia epiphytica
Nitzschia fonticola
Nitzschia frustulum
Nitzschia hungarica
Nitzschia hybrida
Nitzschia kutzingiana
Nitzschia palea
Nitzschia romana
Nitzschia sigmoidea
Nitzschia sublinearis
Nitzschia sp.
Pinnularia subcapitata var. *paucistriata*
Rhoicosphenia curvata
Surirella ovata
Synedra acus
Synedra ulna var.*contracta*

GREEN ALGAE (CHLOROPHYTA)

Cladophora
Microspora
Mougeotia
Oedogonium
Spirogyra
Ulothrix

BLUE-GREEN ALGAE (CYANOPHYTA)

Oscillatoria
Spirulina

RED ALGAE (RHODOPHYTA)

Audouinella

up 26.3%. Burbot, channel catfish and sauger accounted for 9% of the total.

B. Tongue River

At present the Tongue River provides one of the most diverse sport fisheries in the state. Popular sport fish in the Tongue include rainbow trout, brown trout, smallmouth bass, northern pike, rockbass (Ambloplites rupestris), sauger, walleye, channel catfish, and shovelnose sturgeon.

Three sections were electrofished on the Tongue River prior to spring runoff in 1973 to determine species composition and distribution. The sections are described as follows: National Fish Hatchery Section (I), 1.5 miles above the mouth; Viall Section (II), 60 miles above the mouth; and Birney Section (III), 92 miles above the mouth (Elser 1974a).

The electrofishing catch is summarized in Table 10-80. Sixteen species were taken in the three sections; Sections I and II had 12 species each, and Section III had 11 species. Longnose suckers predominated the catch in Section I, followed by goldeye and flathead chubs. The catch in Section II was dominated by flathead chubs, shorthead redhorse, and stonecats, and in Section III by shorthead redhorse and stonecats (Elser 1974a).

Goldeye were taken only in Section I, suggesting that the T and Y Diversion Dam located 12 miles upstream from the mouth is acting as an effective barrier to upstream movement. Smallmouth bass were taken only in Section III, while sauger were taken in all three sections. Young-of-the-year smallmouth and sauger in the samples indicate both species are reproducing successfully in the Tongue River (Elser 1974a).

Four seine hauls immediately downstream from the Tongue River Dam in April 1973 produced 488 fish. Longnose suckers and shorthead redhorse dominated the sample. However, ten trout (six rainbow and four brown) and one northern pike were taken and tagged. Rainbow trout are planted below the dam. Brown trout are not planted but have limited natural reproductions (Elser 1974a).

Sampling in the lower Tongue during the spring of 1974 provided data which indicate the Tongue may be important as a spawning area for several species of fish moving into it from the Yellowstone. Electrofishing runs in the National Fish Hatchery section from late April through May of 1974 produced 155 sauger. Many males were ripe and apparently ready to spawn. The sauger taken during this sampling period ranged in length from 9.9 to 22.8 inches and in weight from 0.28 to 4.20 pounds. The average length and weight were 15.0 inches and 1.11 pounds. Five walleye were also taken during this sampling period and ranged from 11.5 to 26.0 inches in length and from 0.47 to 9.25 pounds in weight.

Shovelnose sturgeon were also found seasonally in large numbers in the lower Tongue below the T and Y Diversion Dam. Four hundred and eleven shovelnose sturgeon were taken during the period from April 24 to June 11, 1974, by drifting large mesh gill nets (2.5 to 4-inch mesh) in the National Fish Hatchery Section. These fish apparently migrated into the Tongue

Table 10-80

Summary of Electrofishing Samples from the Tongue River, Spring 1973, Expressed as Number of Fish per Mile of Stream (Elser 1974).

Species	Section I[1]	II[2]	III[3]
Goldeye	32.4	-	-
Carp	3.6	1.3	5.5
Flathead chub	25.4	53.1	1.5
Longnose dace	1.0	7.5	1.0
River carpsucker	4.3	2.5	5.0
Shorthead redhorse	4.3	45.5	109.5
Longnose sucker	39.6	8.8	8.5
White sucker	1.0	18.5	9.5
Mountain sucker	-	4.3	-
Black bullhead	-	1.0	-
Stonecat	1.0	30.5	33.0
Burbot	1.0	-	-
Rock bass	-	5.5	1.0
Smallmouth bass	-	-	1.0
Sauger	4.3	1.0	1.0
Walleye	1.0	-	-
Total	118.9	179.5	176.5

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[1] National Fish Hatchery Section, 1.5 miles above mouth
[2] Viall Section, 60 miles above mouth
[3] Birney Section, 92 miles above mouth

from the Yellowstone to spawn. Their length ranged from 22.0 to 42.0 inches and their weight from 2.10 pounds to 15.50 pounds, with averages of 32.0 inches and 5.33 pounds. Many shovelnose sturgeon taken from the Tongue River were larger than any previously reported. Blue suckers - (Cycleptus elongatus) were also present in large numbers and in spawning condition during this period (Peterman 1974a).

C. Powder River

Due to the extremely turbid nature and seasonally low water conditions of the Powder River, only a limited sport fishery is provided. Shovelnose sturgeon are taken by anglers as far upstream as Broadus, and channel catfish are also commonly caught along most of its length. Landowners along the Powder report having snagged paddlefish near Locate (Elser 1974b).

Seining six locations during the summer of 1973 produced seven species, including flathead chub, sturgeon chub (Hybopsis gelida), channel catfish, goldeye, river carpsucker, carp and stonecat.

10.1.9.3. Reservoirs

Sport fishing in southeastern Montana is supported primarily by a large number of ranch and farm ponds. These ponds vary in size from less than 1 acre to over 100 acres, but are generally between 5 and 20 acres. The primary consideration in pond construction is livestock watering, with sport fishing a secondary benefit.

Most of these ponds are managed for warm water species, usually northern pike, walleye, and largemouth bass. Some ponds are suitable for rainbow trout and are planted on a regular basis (Elser 1974a).

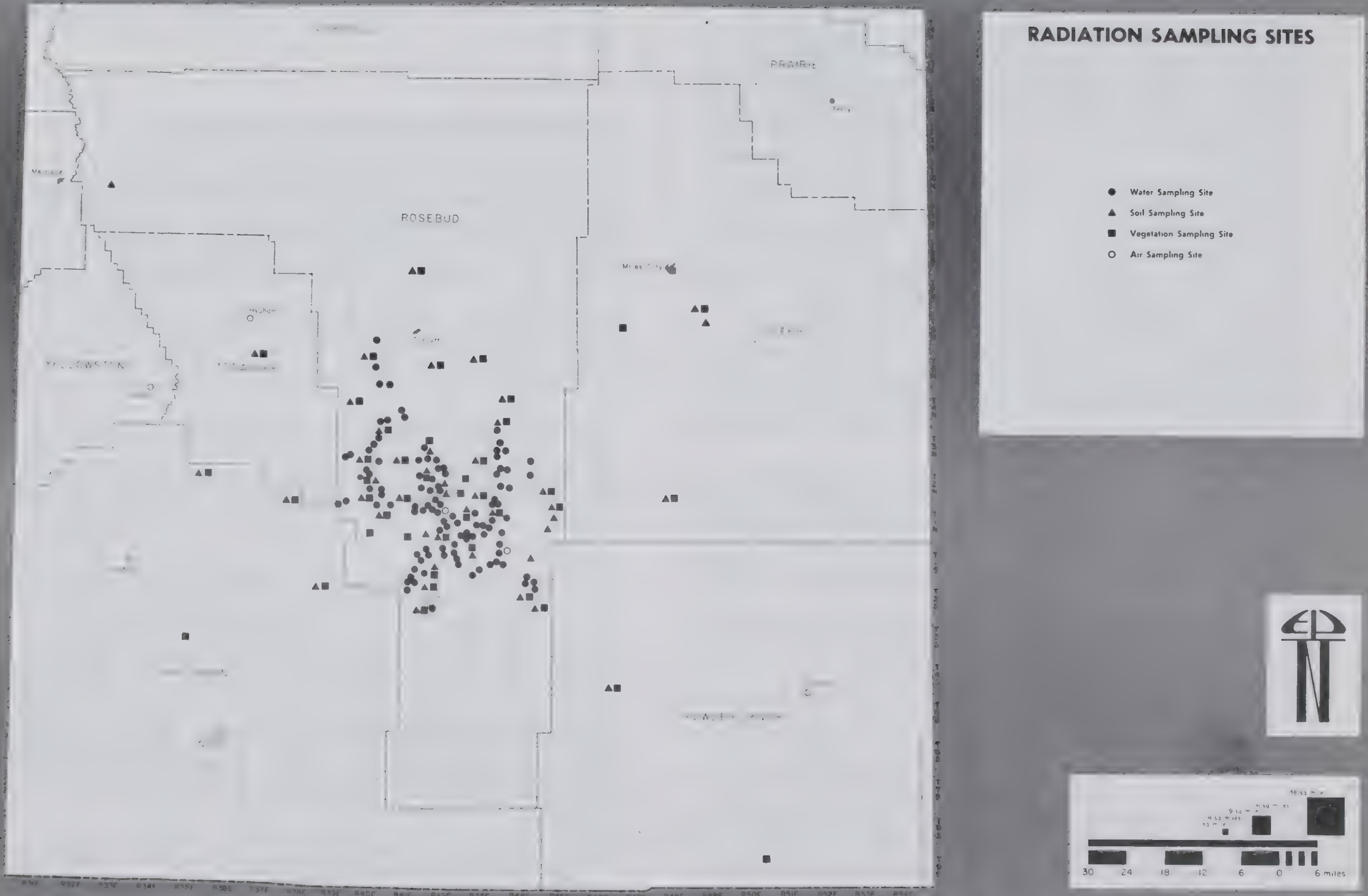
The physical nature of these ponds and their fish populations are constantly changing; therefore, they are under intense management to provide quality fishing. Presently there are 50 such ponds within a 40-mile radius of Colstrip.

One large impoundment, the Tongue River Reservoir (3,500 surface acres), is located near the Montana-Wyoming border and provides a variety of warm water fishing for walleye, northern pike, smallmouth bass and crappie.

10.1.10. Radiation

The radiation studies conducted at Colstrip include analysis of ground and surface water, air, soil and vegetation samples. The purpose of the studies was to identify baseline radioactivity levels in the Colstrip area. The sites selected for study of each parameter mentioned above are shown on the accompanying Radiation Sampling Site Map. These sites are further described in Appendix E1. Appendix E2 contains detailed explanations of the laboratory methods and procedures used to analyze all of the samples collected for study.

The results of the sample analyses performed for water, air, soil, and vegetation are presented in tabular form in Appendix E3. As -



RADIATION SAMPLING SITES

- ● Water Sampling Site
- ▲ Soil Sampling Site
- ■ Vegetation Sampling Site
- ○ Air Sampling Site

expected, all values presented in Appendix E3 are considered "normal", i.e. no unusual or unexpected concentrations were found for any of the parameters measured. Therefore, besides establishing the radioactivity levels that currently exist in the Colstrip area, the principal value of the data will be for comparison to document possible changes after Colstrip Units 1 and 2 have gone on-line, together with the possible changes resulting from Units 3 and 4 if they are built.

10.1.10.1. Radioactivity Content of Water

Surface waters flow in a northerly direction in the Colstrip area whereas hydrology reports indicate that ground water flow is in a southeasterly direction and that both the Rosebud and McKay coal seams are aquifers.

There is a possibility that the radioactivity content of the Colstrip area waters could be altered by disturbances of the coal seams or by leaching from slurry ponds or ash disposal pits.

To acquire baseline radioactivity data on Colstrip area waters, ground seepage waters; spring waters; creek waters and well waters were sampled. Representative water samples were collected in locations of water movement where accessible within an approximate 25 mile radius of Colstrip. Sampling locations including type of water sample, i.e., spring, well, stream, etc., and well depths, when known, are indicated in Appendix E1. These locations are also shown on the Radiation Sampling Site Map included in this section.

The techniques used in preparing and analyzing the samples are presented in Appendix E2. Tables 1-4 of Appendix E3 contain the analysis results.

10.1.10.2. Radioactivity Content of Soil

Small but measurable increases in soil radioactivity may result after long-term operation of the Colstrip generating plants. This possible increase is attributable to the deposition on the soil of particulates from stack effluents. Thus, a network of sampling locations was established to obtain data concerning existing radioactivity content of the soil, which can be used as a baseline for future radioactivity monitoring.

To facilitate sample collection and assessment of the overall radiation impact of the proposed generating plants, soil samples were generally collected at vegetation sampling sites. These sites were established by Dr. C.C. Gordon's vegetation study group and by the Air Quality Bureau. In addition, silt samples were collected from East Fork Armells Creek, Rosebud Creek and the Tongue River. Soil sampling sites and sample identification numbers are listed in Appendix E1 and are shown on the Radiation Sampling Site Map.

Approximately 500 grams of soil were collected at each sampling site. In each location, a composite soil sample was prepared from five different points. Soil was sampled to a depth of one inch.

Gross beta and gross alpha activity found in Colstrip area soil samples is presented in Table

5 of Appendix E3. A discussion of the preparation and analysis techniques used on the samples is presented in Appendix E2.

10.1.10.3. Radioactivity Content of Vegetation

Vegetation samples with the exception of aquatic vegetation samples were supplied by Dr. C.C. Gordon. Aquatic vegetation samples were collected from East Fork Armells Creek, Rosebud Creek and the Tongue River.

Vegetation sampling site locations are listed in Appendix E1 and are shown on the sampling site map included in this section (see Figure 10-28 in Section 10.1.6.6. for cross reference). Gross beta and gross alpha activity levels in vegetation samples are presented in Appendix E3, Table 6. The preparation and analysis techniques used on the samples are presented in Appendix E2.

10.1.10.4. Radioactivity Content of Air

Two air sampling sites were selected, after consultation with the Air Quality Bureau of HES to represent the ambient environment of the area. These sampling sites were also selected to monitor possible changes in ambient levels of airborne radioactivity after Units 1 and 2 go online, and Units 3 and 4 if they are built.

The sites selected were (1) the Burlington Northern (BN) Site and (2) the McRae Site. The locations of these sites are shown on the Radiation Sampling Site Map.

High-volume air samplers were used to collect airborne particulates on fiberglass filters. The fiberglass filter selected offers a high filtering efficiency for submicron particles with a minimal pressure drop throughout the sampling period.

Each filter was numbered and placed in the high-volume sampler where air was passed through it for 24 hours. A calibrated rotameter reading was made before and after each 24-hour sample was taken. The average of these flow rates was used to determine the total air volume which passed through the filter. Two 24-hour samples were collected weekly at each sampling site beginning November 18, 1973, and continuing through June 30, 1974.

Tables 7 and 8 in Appendix E3 show the gross beta activity in air samples which were collected between November 19, 1973 and June 29, 1974 at the Burlington Northern and McRae air sampling sites.

10.2. Cultural Environment

10.2.1. Existing Land Use

10.2.1.1. Land Use Categorization

A. Linear Patterns

1. Transportation

Existing roads and highways, railroads, airports, and landing strips in the study area are shown on the Land Use Linear Patterns-Transportation map.

a. Roads and Highways

The major transportation corridor is Interstate 94, which follows the Yellowstone River closely; widening and improvement of this freeway has not been completed in all locations. Interstate 90 runs through the southwestern corner of the study area, and U.S. 312 connects Miles City and Broadus. Of outstanding importance because of narrowness, rough pavement, and doubtful safety is Highway 315 from I-94 to Colstrip. From Lame Deer to the edge of the Northern Cheyenne Indian Reservation, this road is in serious disrepair and in need of paving. The greatly increased volume of traffic over this road since construction began at Colstrip has hastened its deterioration and focused local attention on its inadequacies. In response to local and company appeals, the State Highway Department has recently assumed responsibility for maintenance and improvement of this road and has plans to repave it. Provision may have to be made by the Highway Department to cross or overpass a road and rail line proposed to serve new mining areas of the Western Energy Company west of Colstrip. Estimates for the reconstruction of the road from Colstrip to I-94 have ranged from $60,000 to $80,000 a mile, although a Western Energy official stated recently that he expected the final cost to exceed $100,000 a mile, or roughly $3 million for the entire thirty-mile segment. Route 212, a state-maintained road connecting Crow Agency and Broadus, is in better condition and was recently improved over part of its distance from Lame Deer to Busby.

b. Railways

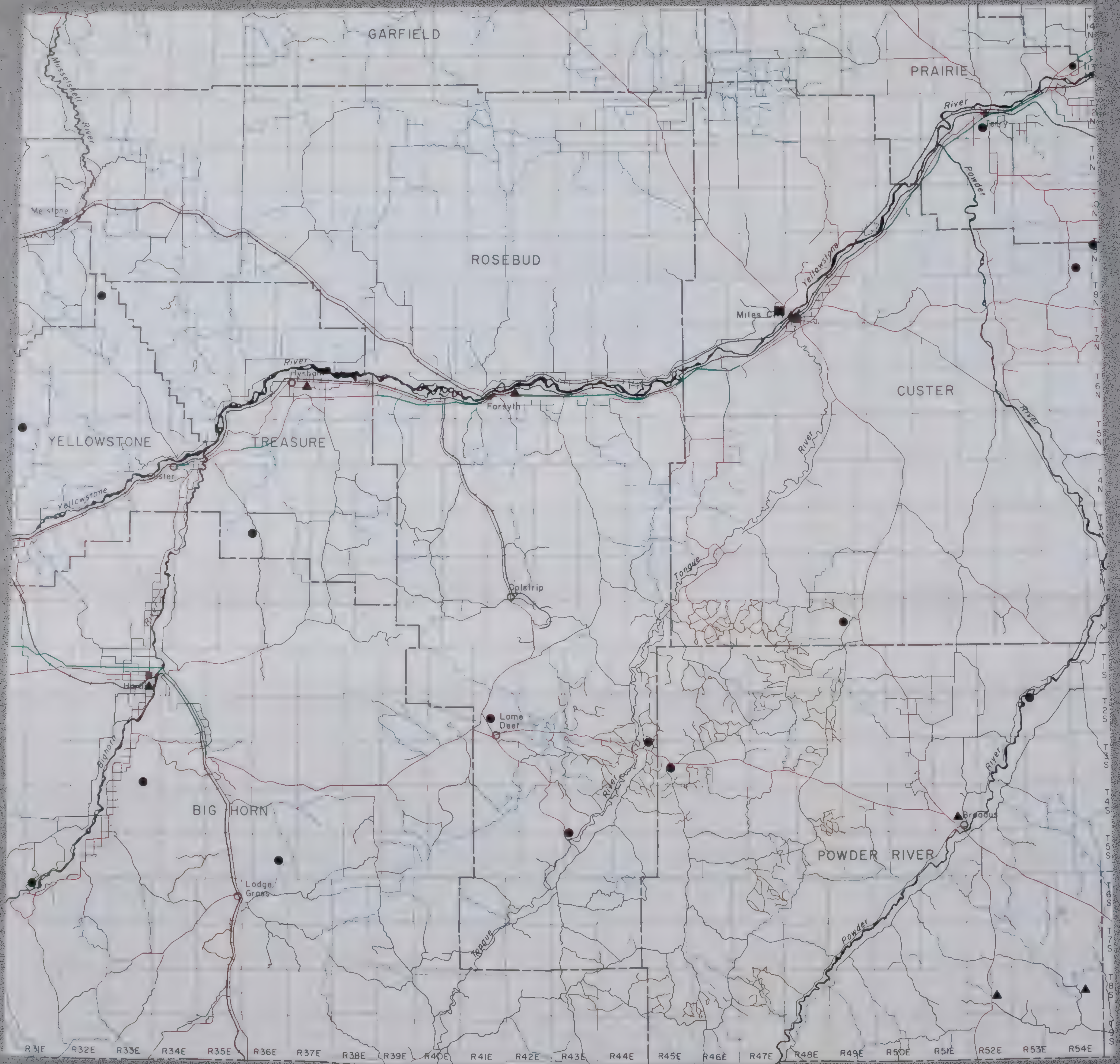
A Burlington Northern freight line follows the Yellowstone River, and a spur line connects Nichols to Colstrip and Cow Creek. Another BN line follows I-90 through Hardin and south into Wyoming. A Chicago, Milwaukee, St. Paul and Pacific line runs east and west, paralleling the BN line from Forsyth to Terry. Amtrak offers daily east-west passenger service along the Yellowstone River.

c. Airports

The only major public airline regularly serving the study area is Frontier Airlines. A major airport is located near Miles City. Runway expansion at the Forsyth airport is being planned and will be financed with 25% county and 75% federal funds. When completed, the runway will be able to accommodate business jets and smaller commercial aircraft. At present, limited charter service and flying instructions are offered by

EXISTING LAND USE

LINEAR PATTERNS/Transportation



RAILROADS

ROADS

Freeway

Paved Highway

Gravelled

Unsurfaced

Primitive

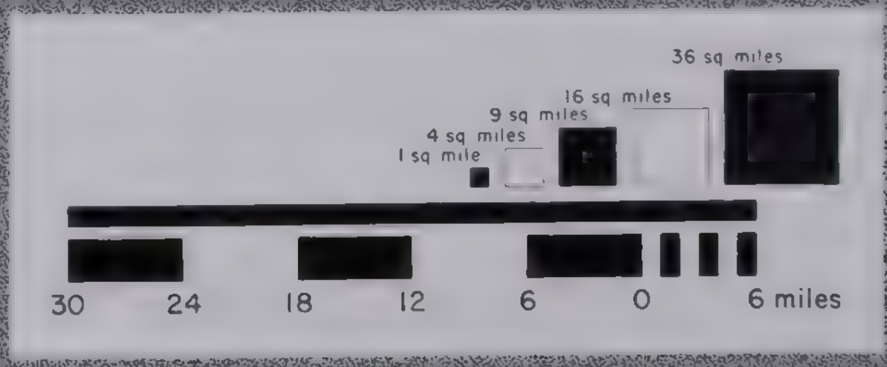
AIRPORTS

■ Large Public

▲ Small Public

● Private

SOURCE MT Highway Dept, IGR, U.S Dept of Commerce
B.N. Amtrak MT Aeronautics Commission USFS



the base operator. Smaller airports and landing strips are scattered throughout the study area.

2. Utilities

Existing transmission lines and gas and oil pipelines are shown on the Land Use Linear-Patterns-Utilities Map

a. Electric Transmission Lines

Three 230 KV lines, owned individually by Pacific Power and Light, MPC, and the U.S. Bureau of Reclamation, a 161 KV Pacific Power and Light line, and two 115 KV Bureau of Reclamation lines intersect at the Yellowtail Dam power plant. A 115 KV Bureau of Reclamation line leads northeast along the Yellowstone from the hydroelectric plant at Miles City. Montana Power Company owns a 230 KV line, a 100 KV line, and a 69 KV line which connect Billings and Colstrip. These three lines will transmit some power from two 350 megawatt power plants (Colstrip Units 1 and 2) currently under construction at Colstrip.

b. Gas Pipelines

Natural gas fields are located at Hardin, Liscom Creek, and Pumpkin Creek. A major pipeline runs through Hardin to Forsyth and continues northeastward, sending branches to Terry and the Liscom Creek Field.

c. Oil Pipelines

Several pipelines transport oil from fields clumped in the northwestern and southeastern corners of the study area. A Cenex pipeline transports refined oil products from Billings.

B. Site Patterns

Existing site patterns of land use are largely a function of the availability of water, whether from precipitation or rivers. The importance of rivers as the major determinant of land use patterns is evident if one compares the Land Use Site Patterns Map with the Surface Water Map (see Section 10.1.3.).

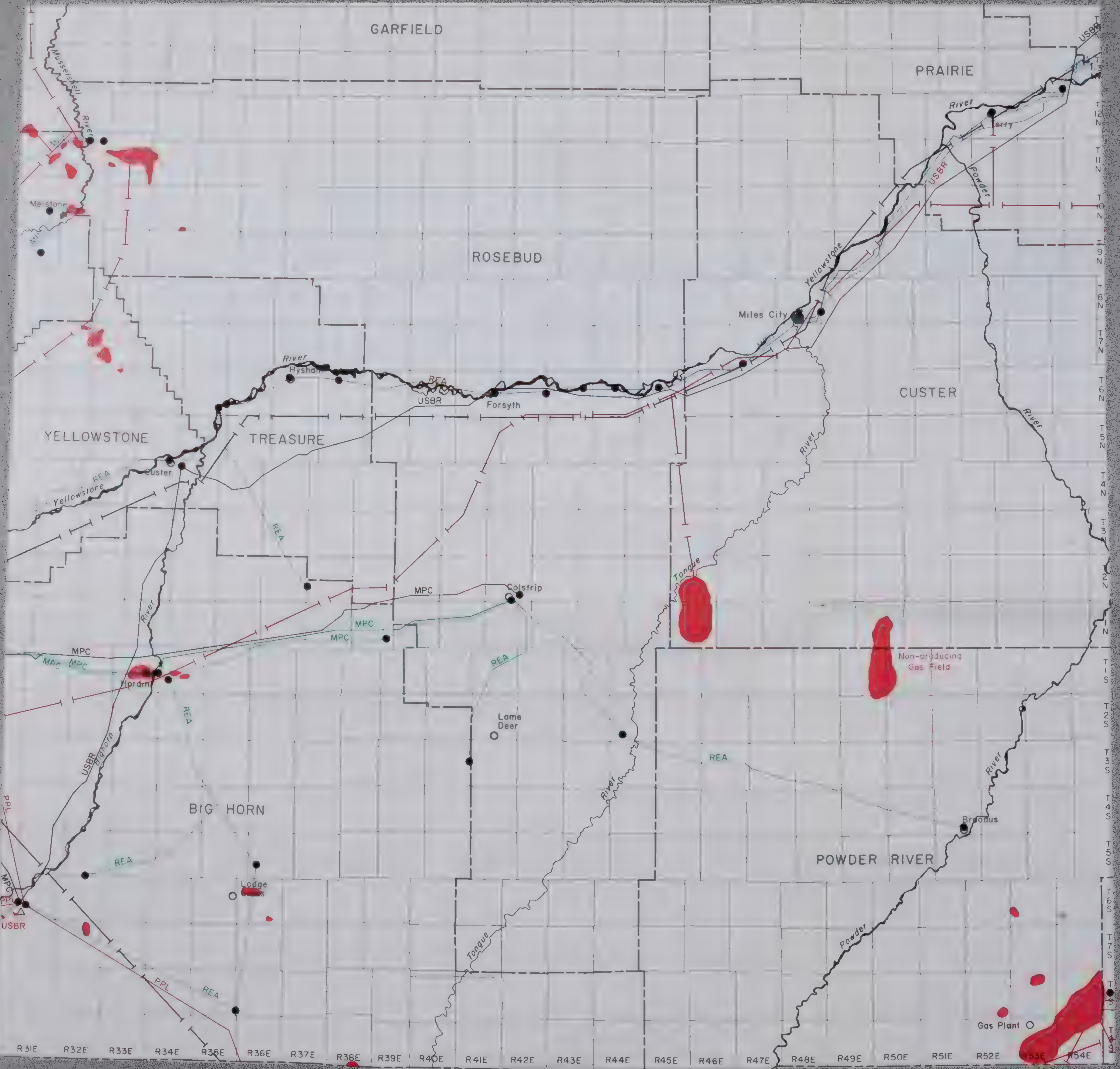
The amount of non-federal land within each of several land use categories for the counties wholly or partly within the study area is shown in Table 1 of Appendix G, "Land Use--1958 and 1967." Definitions for the following land use categories were adapted from SCS (1970).

1. Agricultural Land Use

a. Irrigated Land

Irrigated land is that acreage to which supplemental water is applied on a recurring basis. The study area includes a relatively small amount of irrigated land, mostly concentrated along river valleys and floodplains where water is readily available throughout the summer. Bighorn Lake, Lodge Grass Storage Reservoir, and the Tongue River Reservoir, shown on the Surface Water Map (see Section 10.1.3.), provide a dependable supply of water to several major river valleys.

Irrigated land produces hay, grains, row crops, and pasture; an increasing amount of irrigated land is being used for hay production.



EXISTING LAND USE

LINEAR PATTERNS/Utilities

Natural Gas Pipelines

Oil Pipelines

Refined Products Pipeline

Electric Lines

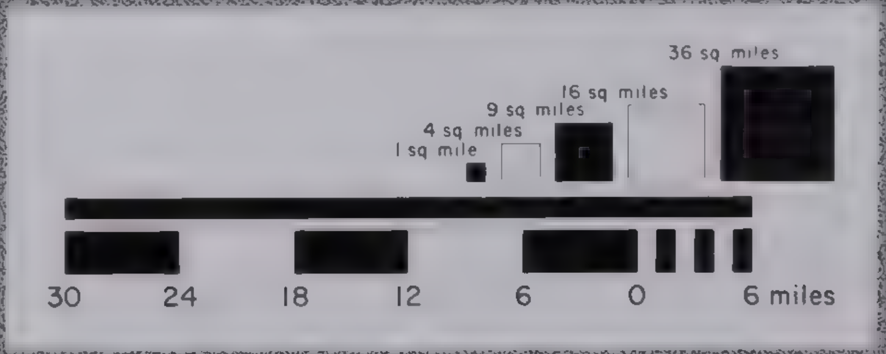
230 KV
161 KV
115 KV
100 KV
69 KV
57 KV
50 KV
34.5 KV

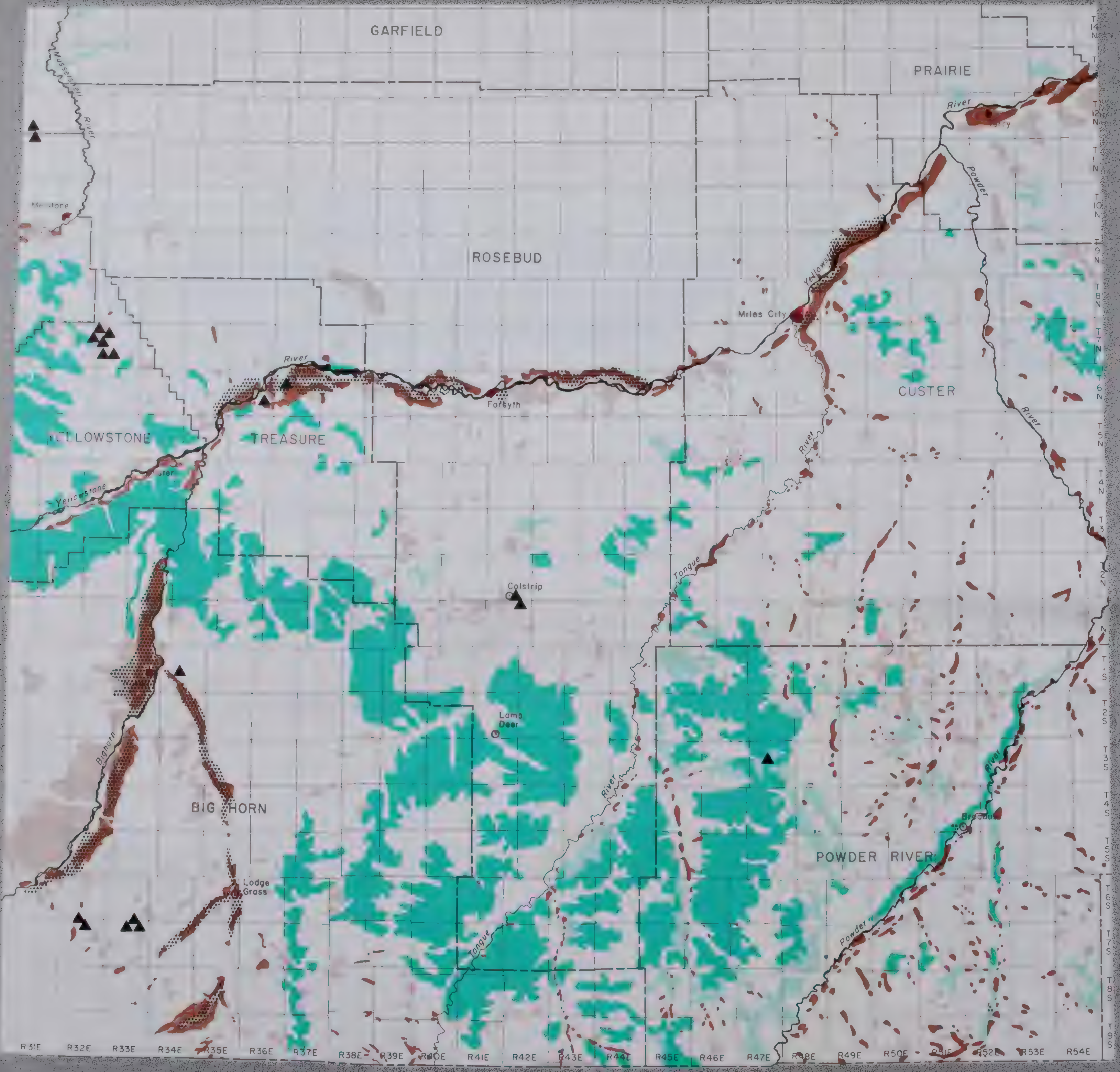
Oil and Gas Fields

● Substations

Power Plants
△ Hydro
▲ Thermal

SOURCE Montana Power Co., Missouri Basin Program conducted by Bureau of Reclamation





EXISTING LAND USE
SITE PATTERNS

- 🟥 Urban Areas & Small Communities
- ▨ Scattered Built-up Areas
- ▲ Industrial Sites
- 🟫 Irrigated Land
- ▢ Dry Cropland
- ▢ Rangeland and Barren Areas
- 🟩 Commercial Woodland
- ▢ Non-commercial Woodland

SOURCE: BLM, SCS, DNRC, ASCS

36 sq miles
16 sq miles
9 sq miles
4 sq. miles
1 sq mile

30 24 18 12 6 0 6 miles

Acreages of both irrigated and non-irrigated cropland are summarized in Table 2 of Appendix G, "Acreages and Production of All Crops, Irrigated and Not Irrigated, 1971." Average yields for irrigated and non-irrigated cropland are summarized in Table 3 of Appendix G, "Average Yields of Cultivated Crops, 1971."

b. Dry Cropland

Dry cropland is that acreage on which crops receive no supplemental water on a recurring basis. The study area contains a relatively small amount of dry cropland, which is scattered in small tracts primarily on upland benches. Wheat, barley, and oats are the most important grains produced in the study area. Types of crops, acreages, and average yields for counties in the study area are given in Tables 2 and 3 of Appendix G.

c. Rangeland

Rangeland is defined as land producing forage plants, either introduced species (pasture) or native species (native range), which are not cut for hay but are generally grazed. The species composition of native range is discussed in Section 10.1.6., Vegetation. Livestock production in the study area, which is summarized in Table 4 of Appendix G, "Livestock Production 1971," is an important use of rangeland. Rangeland also provides food and habitat for a variety of wildlife species.

2. Urban and Residential Land Use

a. Urban Land Use

Urban areas (including cities and towns greater than 2500 in population) and small communities (with populations between 100 and 2500) are centers of high population density, typically containing residences or commercial establishments and crossed by a network of roads dividing groups of residences into blocks. Institutional, commercial, and public administrative sites are usually located within these areas of high population density. Most of the population within the study area is concentrated within a few major towns—Miles City, Hardin, Broadus, Forsyth, and Terry (see Population Density Map included in Section 10.2.3.1.).

b. Scattered Built-up Areas

This land-use category includes towns of less than 100 population, scattered residences with a density of at least five dwelling units per square mile (such as rural subdivisions and trailer parks), large airports, and scattered commercial or institutional sites. Most development of this sort has taken place around urban areas, notably Miles City and Hardin, in the Bell-Creek Broadus area, and in the vicinity of coal mining operations. Table 5 of Appendix G, "Subdivided Land," shows the number and acreages of recent subdivisions for each of the counties within the study area.

3. Industrial Areas

The major heavy industry in the study area is the strip mining of Fort Union coal and the associated mine-mouth generating plants. Important coal mines are the Western Energy Company Mine and the Peabody Big Sky Mine near Colstrip, the Westmoreland Mine at Sarpy Creek, and the Decker Coal Company Mine at Decker. The location and overburden depth of strippable coal deposits in the study area are given by the Montana Bureau of Mines and Geology (1974).

4. Water Areas

Major lakes, rivers, and reservoirs in the study area are shown on the Surface Water Map (see Section 10.1.3.). Acreages of small water areas, i.e. ponds, reservoirs, lakes from 2 to 40 acres in size, and perennial streams less than 1/8 mile wide, are given in Table 1 of Appendix G.

5. Woodlands

Forests in the study area may be classified as commercial forest (capable of producing crops of industrial wood) and non-commercial forests (incapable of yielding crops of industrial wood). Non-commercial forests include riparian cottonwood groves, stands of timber growing on shallow soils in exceptionally dry areas, and stands of timber growing on steep, rocky areas where logging is impractical. The study area contains a relatively small amount of forested land, mostly concentrated within the Custer National Forest.

6. Recreational Land Use

The high plains topography in the approximately 26,000 square mile study area does not have the concentrations of recreational areas and sites found in the mountainous parts of western Montana. Those sites existing in the study area are oriented primarily to the Yellowstone River or Custer National Forest, which has three campgrounds. Additionally, there are two reservoirs in the southwestern part of the study area; the closest is fifty miles from Colstrip. Because of the lack of specific recreation sites, private and public lands in the study area would absorb most of the public's recreational activity.

Ownership of particular sites (public or private) has not been identified on the Recreation and Cultural Features Map, because ownership does not inhibit availability.

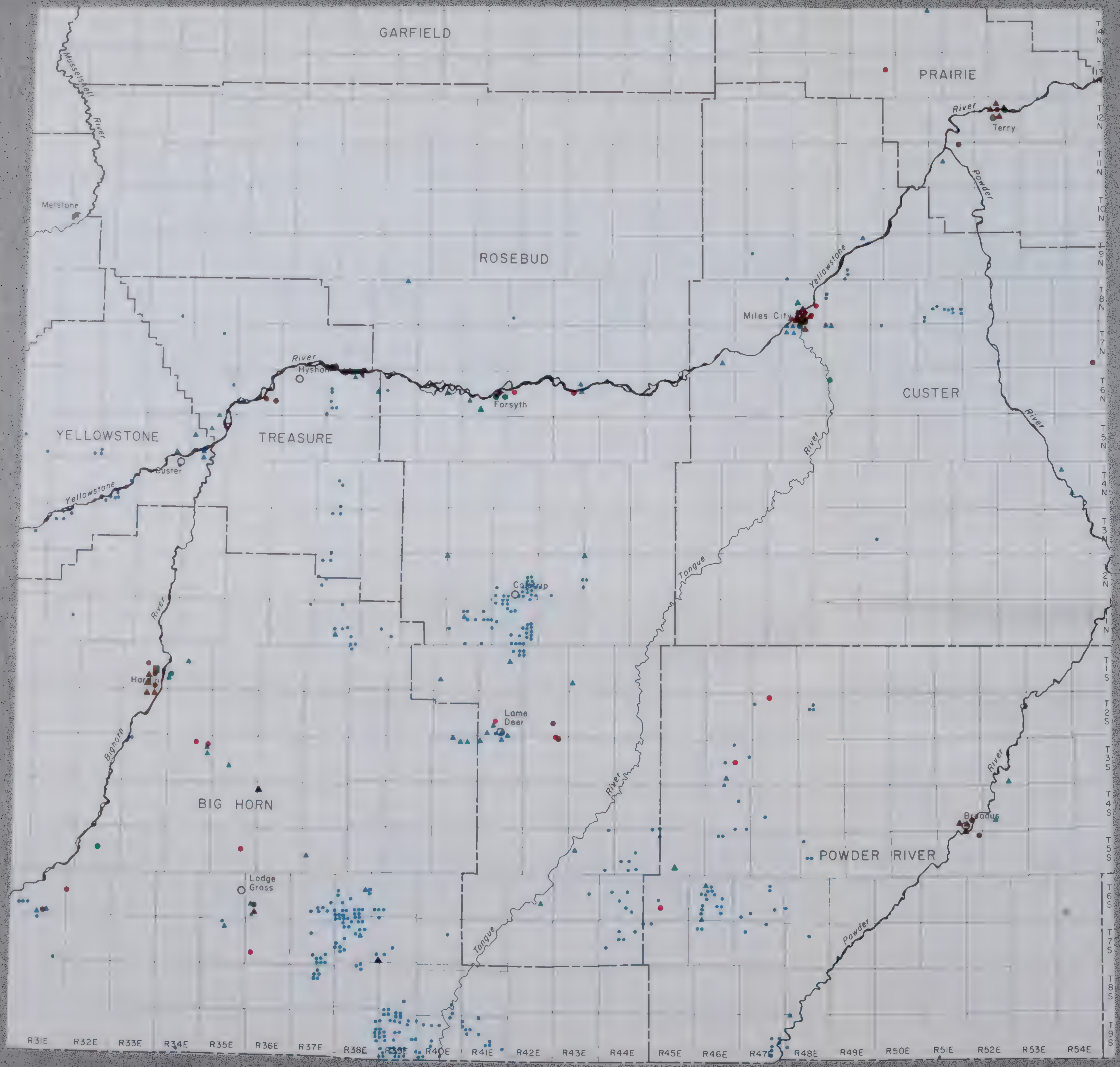
Because of the extensive variety of recreation activities, facilities, and areas, categories have been established to group similar forms of recreation sites and areas. Recreation site categories, as they appear on the Recreation Map, appear below.

a. Campgrounds

Public and private campgrounds, of which there are 21 in the study area, have been mapped. One-third of these are in Miles City.

b. Other Terrestrial-related Activities—Natural-oriented

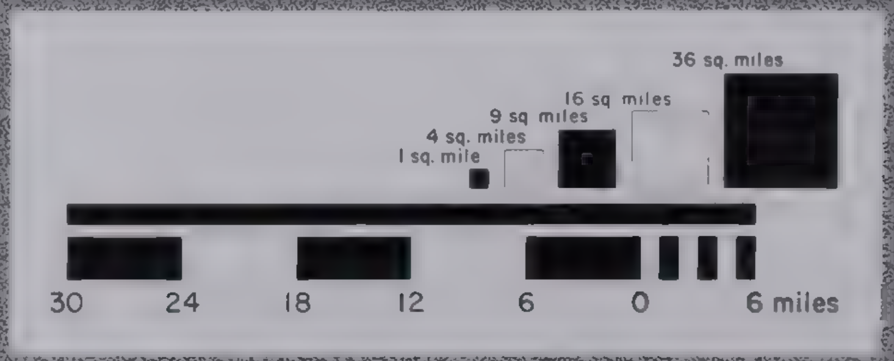
All terrestrial activities in the natural environment, except those defined in categories (a) and (d) are grouped here. There are seventeen of these sites in the study area. The natural environment is the prime factor in the quality of this form of recreation and is an integral part of the success and pleasure of the recreational activity. The elements of this category are



RECREATION AND CULTURAL FEATURES

- ● Campground
- ● Other Terrestrial Related Activities – Natural Oriented
- ▲ Other Terrestrial Related Activities – Cultural Oriented
- ● Other Water Related Activities
- ▲ Point of Interest
- ▲ National Register Historic Site
- ▲ Other Historic Site
- ● Archaeologic Site

SOURCE: F&G, USFS, Dept. of Highways, SCS, DNRC, BIA, Office of the State Forester, BLM



picnic grounds, rest areas, scenic vistas, ski areas, horseback riding facilities, and designated snowmobile trails.

c. Other Terrestrial-related Activities—Cultural-oriented

The site itself is the prime factor for recreational activities in this category, which are primarily urban-oriented. Baseball fields, tennis courts, golf courses, museums, and fairgrounds are included. There are seventeen of these sites in the study area, primarily in the urban centers.

d. Other Water-related Activities

This category includes fishing access sites, boat ramps, swimming areas, marinas, and recreation areas with swimming, boating, and fishing.

e. Point of Interest Sites

There are three point-of-interest sites in the study area. This category combines sites which have a special value for a limited number of people and that are of general interest to many people. The sub-categories inventoried are geologic interest sites, fossil locations, gem fields, mineral locations, ghost towns, and near-pristine areas; it was found that not all of these occur in the study area.

f. National Register Historic Sites

There are three historic sites in the study area that are listed in the National Register of Historic Sites. These sites are particularly important battlefields and places that have been significant in the development of the United States.

g. Other Historic Sites

Sites other than listed in item (g) that are significant in regional, state, and local history have also been mapped, accounting for 59 sites. Some of these are recorded in the Montana Historic Sites Compendium (1974).

h. Archaeologic Sites

Almost 300 sites were documented in the inventory, including sites that have been investigated and those that are known and are awaiting further study. To prevent unauthorized scavenging, the sites are identified only by section.

7. Research Natural Area

The 363-acre Poker Jim Research Natural Area, located about 13 miles east of Birney in the Custer National Forest, is an area designated by the U.S. Forest Service for research and observation because it represents a major timber type in unmodified condition. The U.S. Forest Service permits no physical improvements such as roads, trails, fences, or buildings within Research Natural Areas.

10.2.1.2. Data Sources and Data Collection

The locations of highways within the study area were obtained from the Montana Highway Department's 1974 county maps at a scale of 1"=2 mi. The U.S. Forest Service provided information on recently constructed roads within the Custer National Forest. Locations of railroads were also obtained from the Highway Department maps and checked against railway maps furnished by Burlington Northern (1"=90 mi.) and Amtrak (1"=80 mi.). Locations of airports were obtained from the Montana Department of Intergovernmental Relations (1974), U.S. Department of Commerce (1974), and Montana Aeronautics Commission (1971).

Information on existing transmission lines and substations was furnished by MPC, Montana Dakota Utilities, Bonneville Power, and the U.S. Bureau of Reclamation. Locations of oil and gas fields and pipelines were taken from maps (1"=40 mi.) furnished by the Board of Oil and Gas Conservation (1972).

The location of urban areas, small communities, and some scattered built-up areas was taken primarily from the Montana Highway Department highway maps (1974a) Information on irrigated land and potentially irrigable land was obtained from maps at a scale of 1"=2 mi. prepared by the Water Resources Division of the DNRC. The location of dry cropland was provided by the Water Resources Division for most of Rosebud, Big Horn, Powder River, and Custer Counties. Soil Conservation Service offices provided additional land-use information.

Public agencies, including the Department of Fish and Game, DNRC, U.S. Forest Service, Bureau of Indian Affairs, Bureau of Land Management, National Park Service, Soil Conservation Service, and Department of Highways, were consulted to obtain information on recreation sites they administer. Information from the Bureau of Land Management contract to Western Interpretive Services and the files of the Department of Fish and Game were utilized for data on known historic sites. The Bureau of Land Management contract to the University of Montana and Montana State University was utilized for locations of archaeologic sites. Camping guide publications were reveiwed to obtain information on the locations of private campgrounds. On-site inventories were also made. Guides published for rockhounds were utilized to locate gem, mineral, and rock collecting areas. The files of the Department of Fish and Game provided information on recreational facilities in the urban areas. Locations of game management areas, fish hatcheries, and various wildlife refuges were obtained from published maps and the administering agencies. Ghost town locations were compiled from published books and individuals familiar with the area. Locations of historic markers erected by the Department of Highways were obtained from their publication.

10.2.2. Proposed/Potential Land Use; Land Ownership

10.2.2.1. Proposed/Potential Land Use

Land-use patterns, especially site patterns, are in a continuous state of flux through time. A given sector of land that presently supports a native grassland association may be cultivated and planted in grains the following year, and years later may support other land uses such as irrigation, strip mining, or subdivision. The future development of land use patterns in the study area will largely be a function of the extent of coal-related development in eastern Montana. Strip mining operations and power generating plants preclude or eliminate other land use site patterns, and produce a need for new linear corridors or the improvement of existing corridors for both the transportation of the working force and the transmission of products.

A. Land Use Categorization

1. Linear Patterns

a. Transportation

The Montana Highway Department (1974b) lists plans for no major new transportation corridors through the study area in the period 1974-1979; construction outlined in this five-year plan is primarily maintenance or improvement of existing transportation corridors. Construction is continuing along I-90 and I-94. New roads constructed in the study area will probably lead to new power plants, strip mines, or new transmission lines. New railroad spur lines may be constructed to haul coal from various strip mines in the Fort Union formation. It is unlikely that any new major airports will be constructed in the study area in the near future, although more private landing strips may be created.

b. Utilities

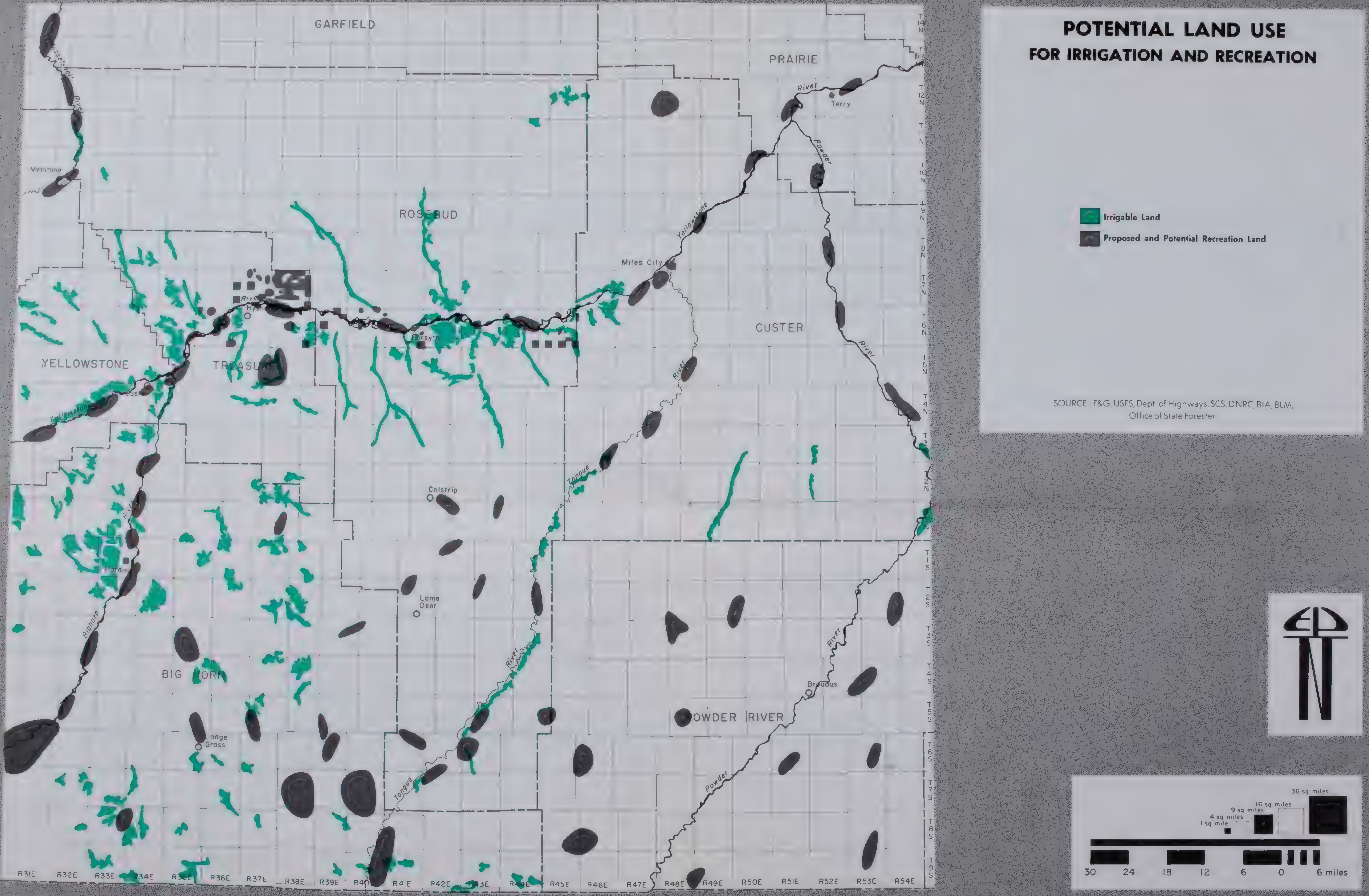
In addition to the Colstrip-Broadview 230 KV line and the proposed Colstrip to Hot Springs twin 500 KV lines discussed in Volume 4 of this impact statement, MPC proposes to build a 115 KV line from Colstrip to Nichols. Other proposed lines are listed in Table 6 of Appendix G. Additional lines may be proposed by utility companies or by local Rural Electrification Associations to serve local need. Any future development of coal-fired power generating plants in the area would necessitate the construction of additional lines. Similarly, pipelines would be constructed to transport products of future coal gasification or other conversion plants which might be constructed in connection with coal development in the study area.

2. Site Patterns

a. Agricultural Land Use

i. Irrigated Land

The locations of potentially irrigable lands are shown on the Potential Land Use Map and were taken from information compiled by the Water Resources Division of the DNRC. The lands classified as irrigable are defined as those lands having "soil, topography and climate that will support sustained irrigated agriculture with proper water management, drainage, and other necessary conservation practices," and which are suitable for irrigation by gravity or sprinkler methods (DNRC, unpublished 1974, p.2). This classification of land as irrigable does not take into account the availability of water for irrigation, market factors of the crops produced, or land use changes that have occurred since the data was obtained. The amount of irrigated land in the study area will probably continue to increase as the technology of sprinkler irrigation is improved, but it is unlikely that much of the



POTENTIAL LAND USE
FOR IRRIGATION AND RECREATION

🟩 Irrigable Land

⬛ Proposed and Potential Recreation Land

SOURCE F&G, USFS, Dept of Highways, SCS, DNRC, BIA, BLM, Office of State Forester

water-remote land will ever actually be irrigated while other lands are already being irrigated.

ii. Dry Cropland

Some dry cropland is located on the potentially irrigable land described above and may someday be irrigated. The recent trend has been toward a decrease in dry crop grain production and an increase in hay and forage production.

iii. Rangeland

The amount of rangeland in the study area will probably decrease in the near future as more rangeland is cropped or committed to other land uses such as subdivision or strip mining. This trend is evident in Table 1 of Appendix G for most counties in the study area.

b. Urban and Residential Land Use

i. Urban Areas

Gustafson (1973) summarizes trends in population change and indicates that in the study area, as in the remainder of the state, there is a net migration of the population from sparsely populated rural situations to urban or suburban areas. During the period 1960-1970, Garfield, Custer, Rosebud, Treasure, and Prairie Counties lost population, the latter two by more than 20%, while Yellowstone, Big Horn, and Powder River counties gained population. The population increase in Yellowstone County is due primarily to the rapid growth of the Billings-Laurel area, which is outside the study area. Although Custer County showed a net loss in population over the ten year period, Miles City showed a population increase of approximately 10%. The population increase in Big Horn County is mainly a consequence of the growth of Hardin, where population increased by more than 27%. The increase in the population of Powder River County is due to the Bell Creek oil boom and the resulting population influx into the Hardin area.

This trend toward movement of population from rural areas to urban centers will probably continue into the next decade, resulting in further growth of urban areas and a further decline in the population of already sparsely populated counties. Coal-related development in the study area will undoubtedly lead to the growth of existing population centers in the vicinity of strip mines and power plants.

ii. Scattered Built-up Areas

This type of development in the study area will most likely consist of new subdivisions or trailer parks appearing in the vicinity of the coal-related developments discussed above.

c. Industrial Land Use

The major area of industrial expansion in the study area will almost certainly be connected with strip mining of coal and the associated mine-mouth generating plants and conversion plants, Montana produced about 16 million tons of coal in 1973, most of this coming from within or near the study area; this is projected to increase to an annual production of 75-80 million tons of coal by 1980 (DNRC 1973). Full employment of Montana's strippable coal reserves would disturb as much as 770,000 acres of land in eastern Montana (Zaidlicz 1972), primarily rangeland, dry cropland, irrigated land, and woodland. The lack of success of reclamation programs in the eastern portion of the state would indicate that part of these 770,000 acres would be taken out of production for a period of years.

d. Woodland

This land use category will probably remain stable, or perhaps decrease as woodlands are removed and replaced by other land use activities.

e. Recreational Land Use

Potential recreation lands (as shown on the Potential Land Use Map) are properties in either private or public ownership which are recognized for attractive natural features, proximity to population centers or other inherent characteristics. They are proposed to meet future demands or are awaiting funding, legislation, or administrative approval for current implementation; the need for these recreation sites will increase if the local population continues to increase. Seven sites adjacent to or on lands with subsurface coal will be directly affected by coal development, which would change the attractiveness of the site for recreation.

Proposed and potential recreation lands were identified by representatives of the Fish and Game Department, U.S. Forest Service, Department of Highways, DNRC, Bureau of Indian Affairs, Bureau of Land Management, and the Soil Conservation Service.

f. Protected Natural Areas

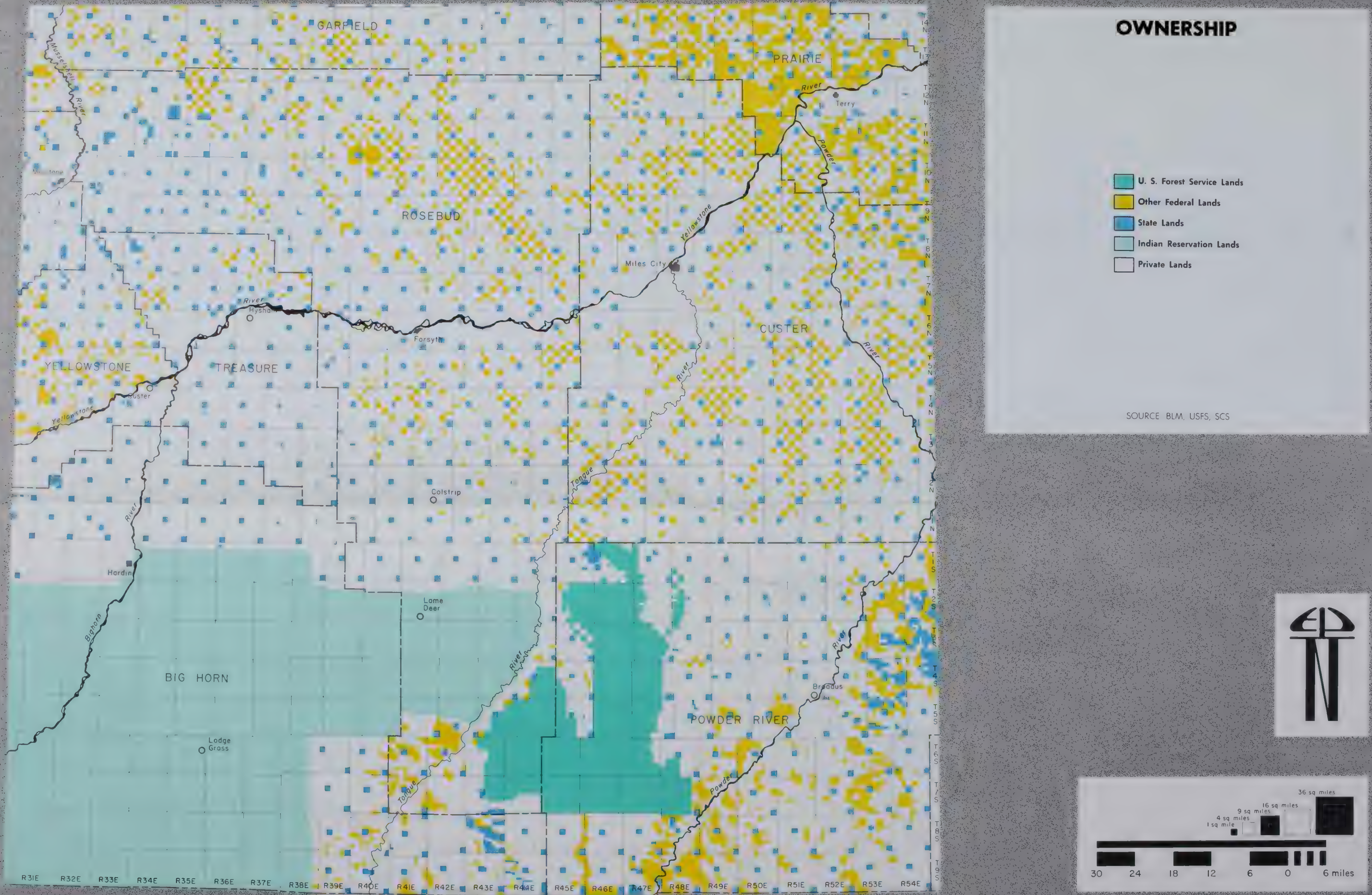
There are no proposed wilderness areas or wildlife refuges in the study area.

10.2.2.2. Land Ownership

The location of lands within the study area owned by the U.S. Forest Service, other federal agencies, the State of Montana, private corporations, individuals, and Indian reservations is shown on the Land Ownership Map.

Forest Service ownership in the study area is confined to Custer National Forest; other federal ownership is administered by the Bureau of Land Management, except for a small amount of land owned by the Bureau of Reclamation. State ownership is scattered throughout the study area, primarily located in sections 16 and 36 of each township. The study area includes the entire Northern Cheyenne Indian Reservation as well as most of the Crow Indian Reservation. The remainder of the land within the study area is owned by private firms and individuals.

The U.S.F.S. provided maps of Custer National Forest at a scale of 1"=2 mi. showing U.S. Forest Service ownership as of 1974. The locations of boundaries of Indian Reservations were obtained from the Bureau of Land Management (1967). The locations of state, other federal, and private individual ownership were obtained both from BLM reclamation maps, at scales ranging from 1"=2.5 mi. to 1"=3.5 mi., and from BLM (1967).



OWNERSHIP

- 🟦 U. S. Forest Service Lands
- 🟨 Other Federal Lands
- 🟦 State Lands
- 🟩 Indian Reservation Lands
- ⬜ Private Lands

SOURCE BLM, USFS, SCS

10.2.3. Social and Economic

10.2.3.1. Population Characteristics

The center of potential population impact resultant from the construction of Units 3 and 4 would be Rosebud County, with a population density of 1.2 persons per square mile (See accompanying population density map). The population of Rosebud County, 6,023 in 1970, declined by 2.5% since 1960, but already this downward trend has been reversed with the development of coal reserves. Units 1 and 2 may well have brought an increase in the population of the county of over 30% between April 1, 1970, and August 1, 1974.

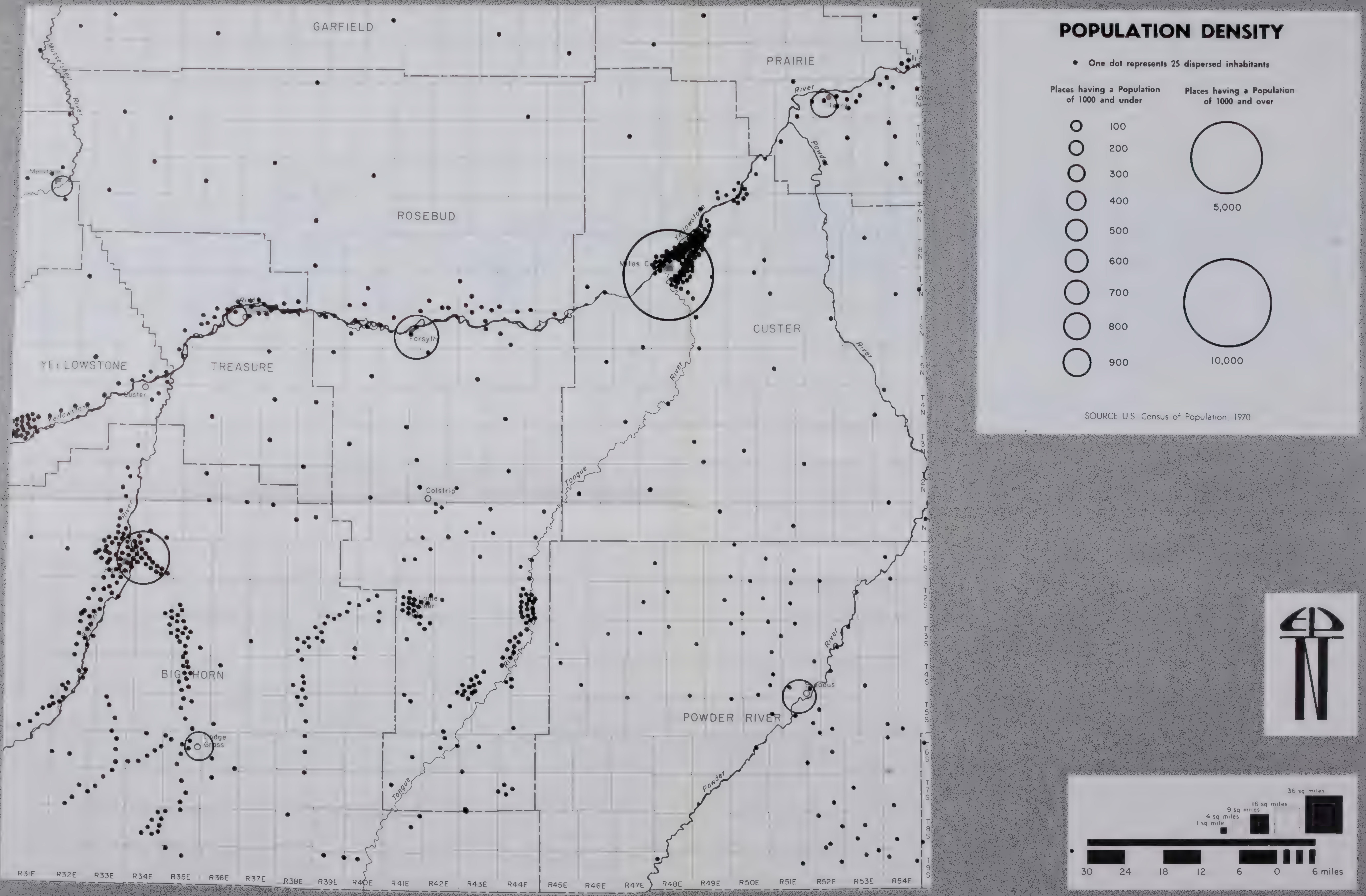
The primary location of growth during this period has been the town of Colstrip, although the county seat, Forsyth, and smaller towns in the area have also experienced considerable population growth. The growth has been so rapid, in fact, that no current record of population has been able to keep up with the actual population growth at either the county or municipality levels.

Growth has largely taken place due to the influx of temporary skilled and semi-skilled construction workers and their families. Accompanying this majority have been supervisory, management and service personnel associated with the Colstrip development. Somewhat independent of this growth has been additional growth associated with coal extraction elsewhere in the county. Traditionally, a rural farm and rural non-farm population, the residents of Rosebud County are rapidly experiencing proportionate increases in non-agricultural workers.

Rosebud County has a large, indigenous minority population. The Northern Cheyenne Indian Reservation, headquarted at Lame Deer, is among the largest reservations in the state, contributing 30% of the total county population in 1970. This percentage is the fourth highest in Montana. Also associated with this particular non-white population are the second highest fertility ratio in the state (473 in 1970), the highest crude birth rate in the state (27.5% in 1970), and the second highest percentage of children under five years in the state.

Rosebud County has had difficulty providing optimal economic characteristics for its residents. 10.3% of the families fell below the poverty level in 1970, the fifth highest such percentage in the state. The mean family income was the fourth lowest in the state in 1970, while per capita income was only one position higher. Consequently, Rosebud County had the second highest percentage of persons on welfare in the state in 1970. Rates of unemployment have been high, and the values of housing have been low. In general, the economic position of Rosebud County has not been an advantaged one.

Educationally, too, Rosebud County has occupied a rather unenviable position. In 1970, Rosebud County fell among the lowest ten counties in Montana for percentage of 14 to 17 year olds in school (14.7% were not in school), average educational achievement by adults (11.5 years), the percentage of elementary school children in public school, and the percentages of male and female high school graduates.



POPULATION DENSITY

● One dot represents 25 dispersed inhabitants

SOURCE U.S. Census of Population, 1970

10.2.3.2. Social Structure

Social structure refers to complexes of human action, thought, and emotion which are shared, repeated in successive situations, and interrelated with other patterns and processes of the social aggregate. That is, a social structure consists of patterns of social relations exhibiting an appreciable degree of regularity. Despite the simplicity of definition, social structures are diverse, complex, dynamic, and multifaceted. It is erroneous to conceive of social situations as being characterized by a unitary, static social structure. Unlike the natural scientist who can often concisely map and inventory the structures, formations, and populations of a given area, the sociologist works with data that is constantly in flux, hidden in subtle nuances, overlaid with tradition, and colored by emotion. To organize and display this data as a complete inventory of a community's social structure is a long, difficult, and painstaking task, beyond the scope of an Environmental Impact Statement. 11/

For this study the analysis of the social impact of coal development does not begin with a detailed compendium of pre and post social structures and processes. Rather, social life within the study area is described, with special attention given to those facets which are experiencing change because of some aspect of coal development. In making this assessment the following three major foci are demarked:

1) An examination of the relationship of man to the natural environment. This focus attempts to understand the perspective social actors hold toward the world around them and how they act in relation to this perspective.

2) An examination of the relationship between social units. This topic is oriented toward understanding how local citizens and newcomers act in relation to one another, considering the life style and perspective of each and how they conflict or coalesce with one another.

3) An examination of area social institutions, their changes, problems, and interrelationships with one another. Special attention is directed at:

   a) The economic institution including discussions of its subcategories i.e., agriculture, retail business, mining, and contract construction.

   b) The educational institution including discussions and evaluations of educational quality and the factors affecting same.

   c) The political institution including a review of local government, governmental planning, and citizen interest in government.

   d) Social stratification including a review of existing patterns of stratification, the place of newcomers, the distribution of power, and the place of minorities.

While the list presented above is by no means exhaustive, a discussion of these major analytical foci, together with a socio-historical portrait of the study area, will render a detailed and relatively complete analysis of the social impact of coal development.

A. The Study Area - Description, History, and Present Situation

Fieldwork concerning the impact of Colstrip Units 3 and 4 on the social patterns and processes (i.e., way of life) of people living in Rosebud and contiguous counties has focused upon the social effects which present plant construction activities have had to date on Colstrip and Forsyth, Montana, including the Decker-Birney-Ashland area, and upon the present and anticipated social impact of strip mining in the area.

1. Description of Principal Communities

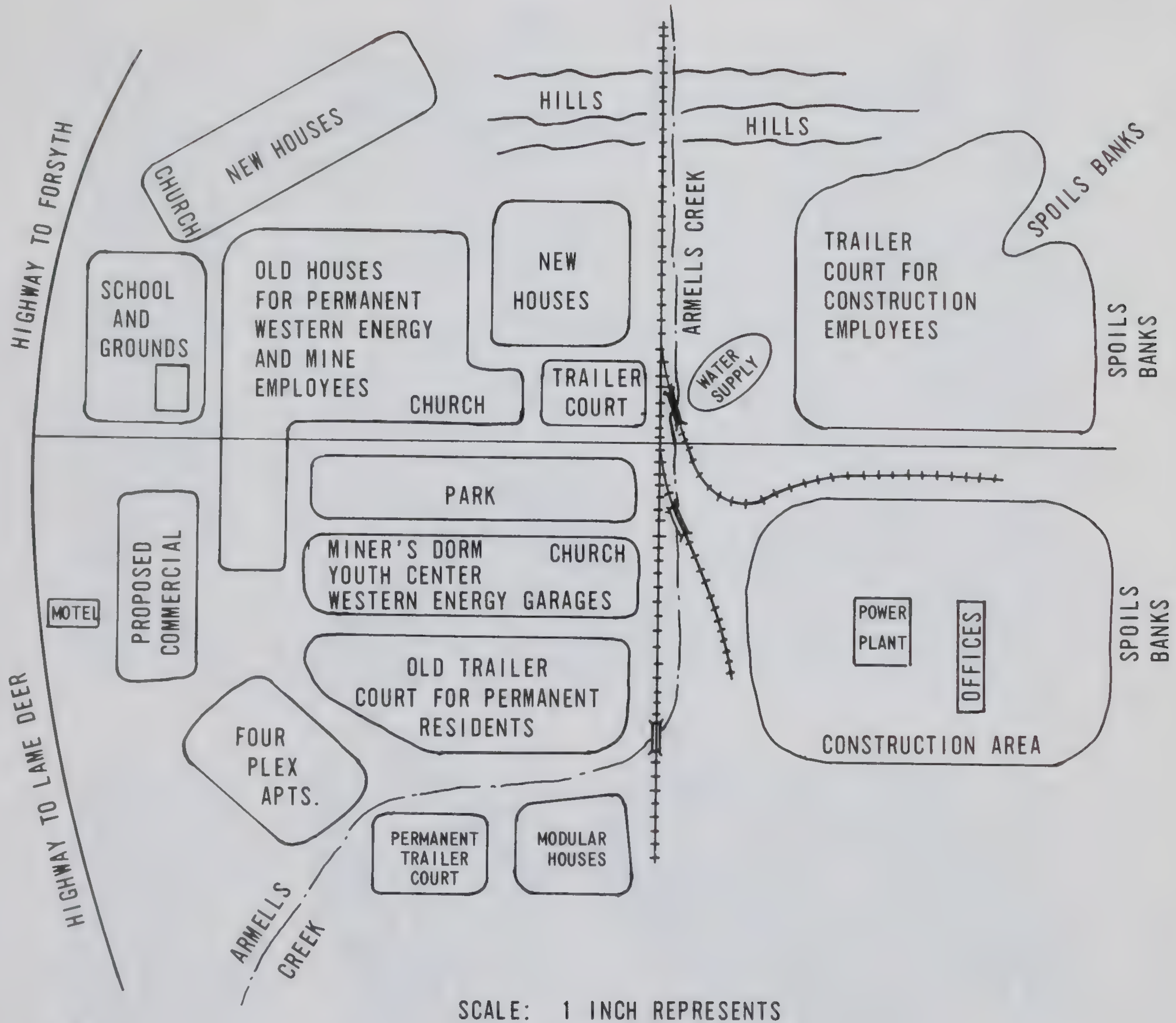
The principal study communities of the area are Forsyth and Colstrip with populations of approximately 2,700 and 1,800, respectively.

Colstrip, formerly a very small community with only a school, post office, and mining activity and populated almost exclusively by teachers and retired people, has become a modern day, burgeoning mining camp with the construction of two coal-fired electric power generating plants under way. Although Colstrip is a one-company town belonging to Western Energy, a wholly owned, coal mining subsidiary of MPC, construction of the two 350-megawatt plants is a joint project of two companies: MPC and Puget Sound Power and Light Company. At present, the town still has virtually no business community or center, although plans have been made for a shopping center (see Figure 10-44). The residents do not walk around town very much because there is little to walk to, and the community appears deserted except during working hours, when evidence of inhabitants is readily visible at the school and post office.

The community of Forsyth, a small town about 35 miles north of Colstrip, is situated in a bowl-like valley, bordered by the Yellowstone River to the north. The casual observer finds the residential part of town, which is located on a flood plain, very pleasant, with trees and other greenery. In contrast, the downtown portion, located one block from the railroad, is quite run down, and remodeling, rebuilding, and general face-lifting activities are reportedly needed to make the commercial center attractive. The community is an established trade center for the area, the county seat of Rosebud County, and the closest town of any size to Colstrip, unless one ventures an additional 45 miles east to Miles City or 101 miles west to Billings. The latter communities are also feeling some effects of coal development in eastern Montana, but Forsyth is directly affected by the construction and mining activities in Colstrip./12 A sketch of Forsyth is presented in Figure 10-45.

2. History of the Study Communities

In 1883, the Northern Pacific's line was completed through and beyond Forsyth, and the town's first school was constructed at that time.

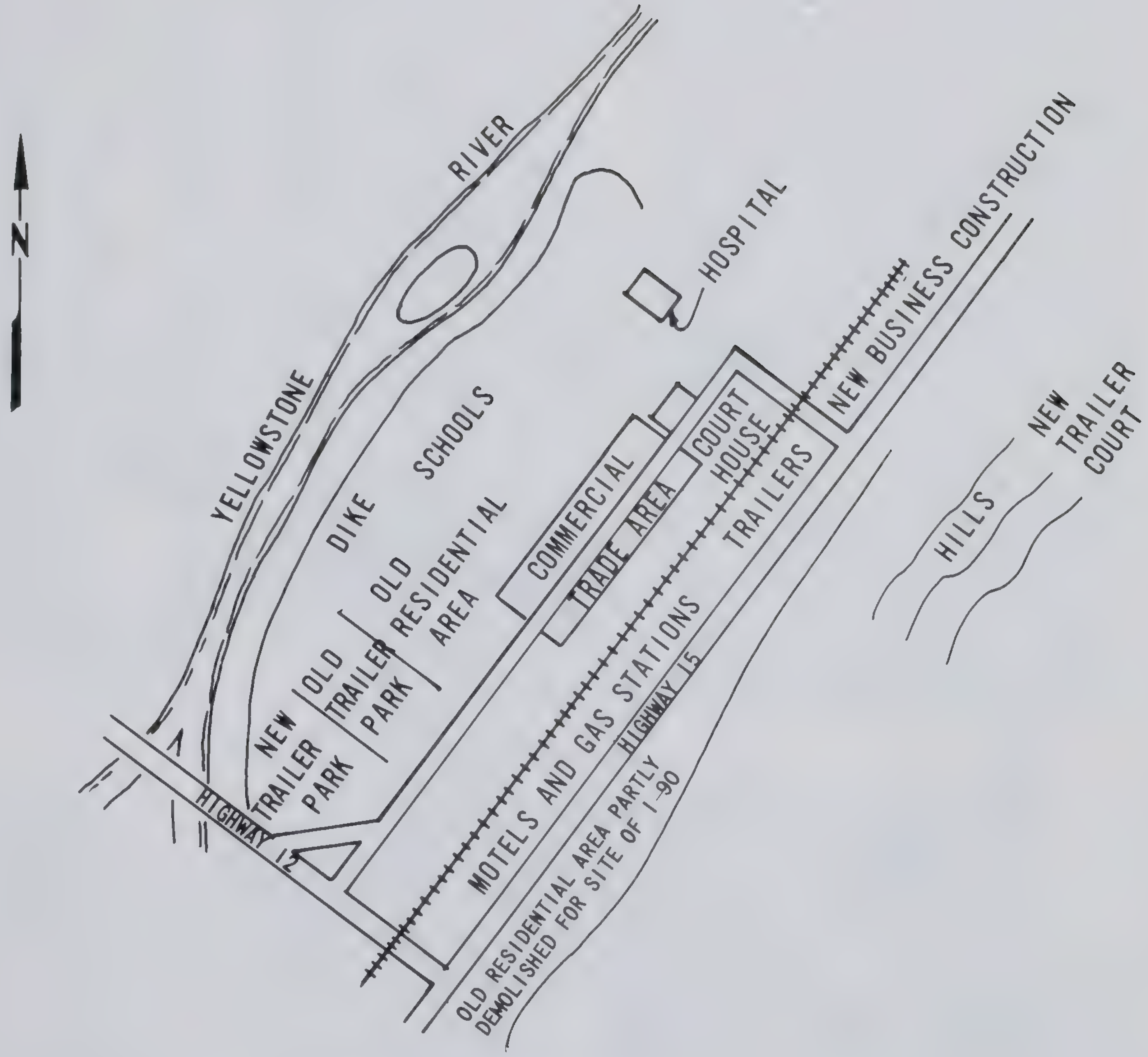


SCALE: 1 INCH REPRESENTS
APPROX. 16 MILES

SOURCE: REASEARCH NOTES

CŌLSTRIP, MONTANA

FIGURE 10-44



SCALE: 1 INCH REPRESENTS
APPROX. .3 MILES

SOURCE: RESEARCH NOTES

FORSYTH, MONTANA

FIGURE 10-45

Forsyth thrived as a railroad division point, as the county seat, and as a shopping and commercial center, reaching its peak in 1923. In that year there were probably close to 2,500 people in town, including five or six medical doctors, an equal number of lawyers, and many businessmen. During the railroad strike of 1923, about 60 families left Forsyth, and a decline began in the town's division point status and in its general fortunes. Mining at Colstrip helped Forsyth through World War II; following the shutdown of Colstrip's mine in 1959 there was a reduction in the number of railroaders at Forsyth, and the town's economy stagnated until revitalized by plant construction at Colstrip in 1973.

The strip mine at Colstrip which opened in 1923 was owned by Northern Pacific and operated by its subsidiary, Northwestern Improvement Company. The researchers were told that the large production in the 1940's "was similar to what it will be in 1974." Colstrip's school opened in 1924; Northwestern Improvement Company gave the school to the county (i.e., the local school district) in 1957, just two years prior to closing its mining operations. The mine was sold to MPC on June 1, 1959, and reopened in 1968.

3. Present Economic Situation and Planning Picture

Interviewers report that Forsyth is experiencing an economic boom from the construction and mining activities at Colstrip and from local railroad expansion being done to accommodate coal shipping needs. It was also pointed out that the past year has been outstanding for agriculture, which has contributed to the local economy.

Indications of recent growth are quite visible; for example, trailer courts are much in evidence due to the sudden housing shortage. There is also a shortage of labor at all levels, but business is excellent. The labor shortage is attributed to the profitable employment opportunities at Colstrip, which are attracting workers from Forsyth, elsewhere in eastern Montana, other states, and Canada./13 Unskilled laborers, for example, are being paid as high as five to six dollars per hour. However, people in Forsyth and neighboring towns /14 for the most part perceive that the price of everything seems to be rising fast and incessantly; hence, the value of increased earnings is being eroded.

The economic boom has also created a severe land shortage. The demand for land, especially for small acreage, has soared. Many newcomers desire up to 15 acre spreads, where they can put a trailer house, erect a chicken coop, keep a horse, or simply let the dogs run. There is no set price for these smaller peices of land; in fact, nobody wants to sell. Real estate agents and others are trying to interest ranchers in subdividing but so far have not been successful./15

Houses in Forsyth, when available, are selling for a third more than they sold for three years ago. One veteran businessman stated, "This is the first time in my real estate experience that I haven't had a house for sale." Living in a trailer court, which is the only alternative for the present, provides much less privacy than the occupants desire because there is so little space between neighbors, but at the moment land space is unavailable for purchase at any price.

The increases in land values have been accompanied by increases in rent, housing problems, and most noticeably, taxes. Older persons who have lived in the area for decades have found that their property values have increased substantially, but there is no inexpensive housing for these senior citizens to move into should they decide that it would be in their best interests to sell. Their property taxes may continue to rise with the current economic boom, perhaps eventually forcing many to sell when they can no longer meet these and other rising homeowner costs on a retirement income. Property tax in Rosebud County increased 15 mills in the last year, in spite of a gain of about $1.5 million in the taxable value of property.

Because Colstrip is a private town, there is no city property tax structure. All residential land and all permanent dwelling units belong to Western Energy. The construction company which has contracted to build the power plants apparently requires that housing provided for its personnel be somewhat segregated. Three major residential areas have been arranged by Western Energy: a temporary trailer court, occupied mostly by construction workers; a permanent trailer court and group of preassembled houses, occupied in large measure by engineers, miners, and supervisory personnel; and a neighborhood composed entirely of single-family permanent homes, both old and new occupied for the most part by permanent employees (executives, teachers, miners, and others)./16 Differences among these residential districts are very noticeable, even to the casual observer. In addition to these housing areas, nine apartment buildings containing four dwelling units each have been constructed, with occupants reportedly carefully chosen so that potential class discord can be averted. Three buildings containing eight apartments each are currently being built. The few older homes that house Colstrip's established residents are in sharp contrast to the predominance of mobile units. Reacting to this aspect of development, one interviewee stated, "Every day I wake up expecting to find that half the town is gone. It's on wheels, you know."

As with housing, Colstrip city planning is entirely under the jurisdiction of Western Energy. Company officials have indicated an interest in starting a town council composed of two representatives from each of the three residential areas./17 The council would function as an advisory board. One newcomer at Colstrip felt that MPC would have to allow for residents' self-determination and to face up to the need to provide normal, small town facilities or else the employees would quit and move away; another stated that many men were already leaving because of their dissatisfaction with the living and working conditions.

In contrast to the situation at Colstrip, city planning in Forsyth is open to the desires of community residents. Earlier in the year it appeared to some Forsyth residents that important and appropriate planning for future town needs was materializing much too slowly because, according to these persons, the city council was shirking its leadership responsibilities. This statement was made in reference to an anticipated water shortage in the summer of 1974. Forsyth's water system has to be modernized and expanded in order to meet the needs of the town's rapidly rising population, and the city council had been reluctant to formulate an appropriate bond issue for submission to the voters in time to allow the necessary overhaul to be completed before a shortage occurred.

A merchant noted that the city council had "a tough problem on its hands" in that there was not enough money and not enough space for city expansion. The town will probably have to expand, but future reclassifications of land for residential and commercial purposes are uncertain. Zoning has reportedly never been enforced. One interviewee observed that trailers have been placed "hither and yon," but this placement has been confined to the edges of town. A city-county planning board was established a few months ago, but whether or not this board will be effective remains to be seen.

The business sector is also having difficulty in planning for Forsyth. A unique opportunity is being presented to them, but local merchants evidently are not making a concerted effort to ready themselves for anticipated commercial needs and related developments. A few appear to be closing their eyes to the potentials of the situation: for example, owners of two of the main downtown buildings are reportedly disinterested in modernizing or expanding them./ 18

One interviewee explained this situation by pointing out that the business community has never engaged in such planning in the past nor has it felt the need to; further, the magnitude of the impact of actual and likely coal development activities "hasn't hit home yet." Also, because the duration of the presently good economic situation is relatively uncertain, there is much hesitation about taking concrete steps to improve the downtown area. The spirit is one of cautious optimism. Interviewees noted that some merchants may be hesitant to expand their businesses because they distinctly remember the five-year boom-and-bust period with the oil development activity around Broadus and Ingomar and fear the same bust may follow the economic boom here. Others stated that they were having second thoughts about certain aspects of continued industrial development, such as the possible appearance of undesirable competition. However, a few individuals have built or are building new and enlarged quarters for their businesses.

The local Chamber of Commerce, although certainly mindful of its developmental responsibilities, has not yet formalized plans for commercial growth. In general, local ranchers, who have always prized independence and self-reliance, are suspicious of or opposed to planning of this nature, which they perceive as an urban effort to direct their rural world. In contrast, an engineer stated that because old-timers were not able to solve new problems, newcomers like himself would have to help—a view which has become increasingly prevalent on both sides.

4. Discussion

Several matters mentioned in the foregoing descriptions of Forsyth and Colstrip merit special attention.

1) Since this research began over seven months ago, many events have had various

kinds of cumulative effects on the residents of the study communities. For example, although people in Forsyth generally still insist that their lives have not been greatly affected by coal-related developments, it is evident that they are wittingly and unwittingly taking coal-related matters into account in more and more ways. Even though they do not perceive and report much social impact, their observable behavior reveals that they are in fact increasingly adjusting their actions to coal-related interventions in their lives. These two kinds of reactions (verbal and behavioral) are not inconsistent, because interviewees still view their adjustments as hardly more than dealing with such minor annoyances as going shopping at unaccustomed times in order to avoid the rush hours created by the newcomers who live in Colstrip. Feelings of impact are especially easy to "gloss over" when, as is true of many Forsyth locals, the increase in economic activity is viewed as if it were the result of a good and prolonged tourist season which is bound to be over before too much longer.

2) The role of newcomers is changing. In Colstrip more evidently than in Forsyth, it appears to be moving along a path similar to that being established at Gillette, Wyoming, where some "newcomers" have been in residence long enough to become quite well integrated into the community. In Gillette, it is the people who have been there for only a few years (strictly speaking, no longer newcomers but still definitely not locals) who are apt to serve as agents as well as catalysts of social change, roles which locals do not seem to play very readily.

3) Concern about planning is increasing in Forsyth, but demonstrated ability in this regard is still not evident. Chronic uncertainty about the future and about the role which local government should play in shaping and preparing for the future is a serious problem but, certain potential solutions exist. For example, government officials at Forsyth could actively initiate schemes for planning and guiding the future growth of the area. Technical assistance could be obtained to help officials explain to landowners what planning could do to increase their chances of enjoying, more fully than otherwise, their rural way of life.

4) Other communities in the study area, such as Ashland, also have high growth potential. Ashland (population 531 in 1970), located along the Tongue River on the northeast corner of a rich coal area, could conceivably become the "boomiest" town in southeastern Montana.

5) In general, the increased flow of money in Forsyth has not yet been socially defined as a major factor in the lives of most of the town's residents. Excepting those who live on small, fixed incomes, people in Forsyth are generally benefiting economically from coal-

related development at Colstrip. However, only a comparative few Forsythians spend much time reflecting on development, talking about it, altering traditional behaviors in consequence or anticipation of development, trying to imagine themselves living very differently as a result of development, and so on. These and other concerns are typically very evident among landowners in the area. The rural people's tendencies to feel anomic, i.e., to feel a sense of powerlessness, normlessness, and what's-the-use-ishness (Durkheim 1933); to experience reality shock, i.e., to feel deluged by a surfeit of social change (Toffler 1970); to scapegoat; and to consider having to reorganize their lives are simply not very evident in town.

6) Social impact results from that which has actually happened and is happening to the study area's residents, and from whatever they anticipate or imagine will happen to them as a result of future coal-related developments. The description of the social impact of power plant construction and strip mining is based upon interview accounts of past and present happenings and upon their effects on those concerned. Anticipating additional industrial interventions, ranchers (and some others) in the study area are already being affected by what they imagine will be the social consequences of such industrialization.

5. Method of Data Collection

Data for the study came from several hundred contacts made during a seven-month period with people living in and around Forsyth and Colstrip, and intensive personal interviews were done with over 200 of the people contacted in the study area. Persons interviewed included both landowners and townspeople in the study communities and surrounding vicinity. The latter represent a variety of occupations and professions, including government officials, merchants, store employees, land brokers, financiers, health professionals, welfare workers, students, educators, laborers, engineers, housewives, clergymen, tribal representatives, law enforcement personnel, senior citizens, newsmen, and lawyers.

The research done for this study employed an ethnographic approach. As detailed in Appendix H1, there are many advantages in this manner of obtaining data on what is happening to the people who are directly and importantly affected by the strip mining of coal, the construction and/or operation of coal-fired electric power generating plants, and the anticipation of further industrialization and urbanization in hitherto rural settings.

Although some social changes resulting from the industrial processing of coal in rural areas were apparent almost at once, others were evident only after several months of investigation, and still others emerged only after much more time has passed. The research task is to systematically record, analyze, and explain these changes as they occur.

This study is an effort to faithfully represent what the identified groups and categories of interviewees perceive, think, feel, and do with respect to the Colstrip generating plants and other coal-related developments. The reader will note some conflicting statements, naturally, since the researchers are reporting what a variety of people told them over a period of time. In the interests of brevity, like comments in several instances have been paraphrased and merged into one quoted statement; all other quotations are verbatim except where editing has been necessary in order to protect the identity of the speaker.

It should be noted that the text expresses the views of the informants; when the authors are speaking for or about a given category of persons, or when one category is speaking for another, it is so indicated. The authors have attempted to make explicit when they themselves are generalizing or commenting about the data, i.e., about what was observed and told to them. Researchers' comments are ordinarily placed in "Discussion" sections following the paraphrasing, quoting, and summarizing.

10.2.3.3. Community Services

The study of social service delivery systems and the impacts which would result from construction of Units 3 and 4 has been conducted solely within Rosebud county, with particular emphasis on the communities of Forsyth, Colstrip and Lame Deer. This is because over 80% of the population influx associated with energy development has centered in Rosebud County./20 While communities such as Billings and Miles City are experiencing some growth related to energy development, their geographic distance from Colstrip militates against large scale population growth in the immediate future. As such, the impact on social service delivery systems in these communities is expected to be relatively small.

Forsyth received special attention in the study of social services because it is the county seat of Rosebud County, and hence the service center for governmental agencies. Also, Forsyth is the largest community in the county both in terms of population and existing commercial services. The population influx related to construction and mining operations at Colstrip has spilled over to Forsyth and has taxed local social services. Colstrip was studied because of the large population increase in the community and its comparative lack of social services. The major intent was to determine the capability of local social services to absorb a large population increase. Lame Deer was studied because it is a major service center for the southern part of Rosebud County, headquarters for the Northern Cheyenne Reservation social service agencies serving tribal members, and located in an area of potential future energy development.

The study of existing social service delivery systems focused on 12 major areas: health care, welfare services, fire protection, law enforcement, public transportation, municipal - services - primarily water and sanitation, education, recreation, planning, housing, commercial services, and churches. The inventory examines both the quantity (e.g. the number of hospital beds, police officers, pieces of fire equipment, etc) and quality (e.g. the degree to which additional hospital beds, police officers, fire equipment, etc are needed) of the social service delivery system. As will be discussed later in Section 11.2.2.3., this inventory data is paired with population projections to determine the impact of Units 3 and 4 on social services.

A. Public

1. Health Care

a. Hospitals

i. Colstrip

Since no hospital exists in Colstrip, patients must travel to Forsyth or Billings for hospital care. However, a first aid station is set up in a mobile home in the town and staffed 10 to 12 hours a day by two nurses (See Figure 10-46). Office space for one physician and one dentist has been allocated in a commercial complex now under construction, but so far neither a physician nor a dentist has located in Colstrip although MPC has guaranteed a yearly physician's salary of $20,000 (White 1974a). For the present, a physician who has just opened practice in Forsyth makes visits to Colstrip one evening a

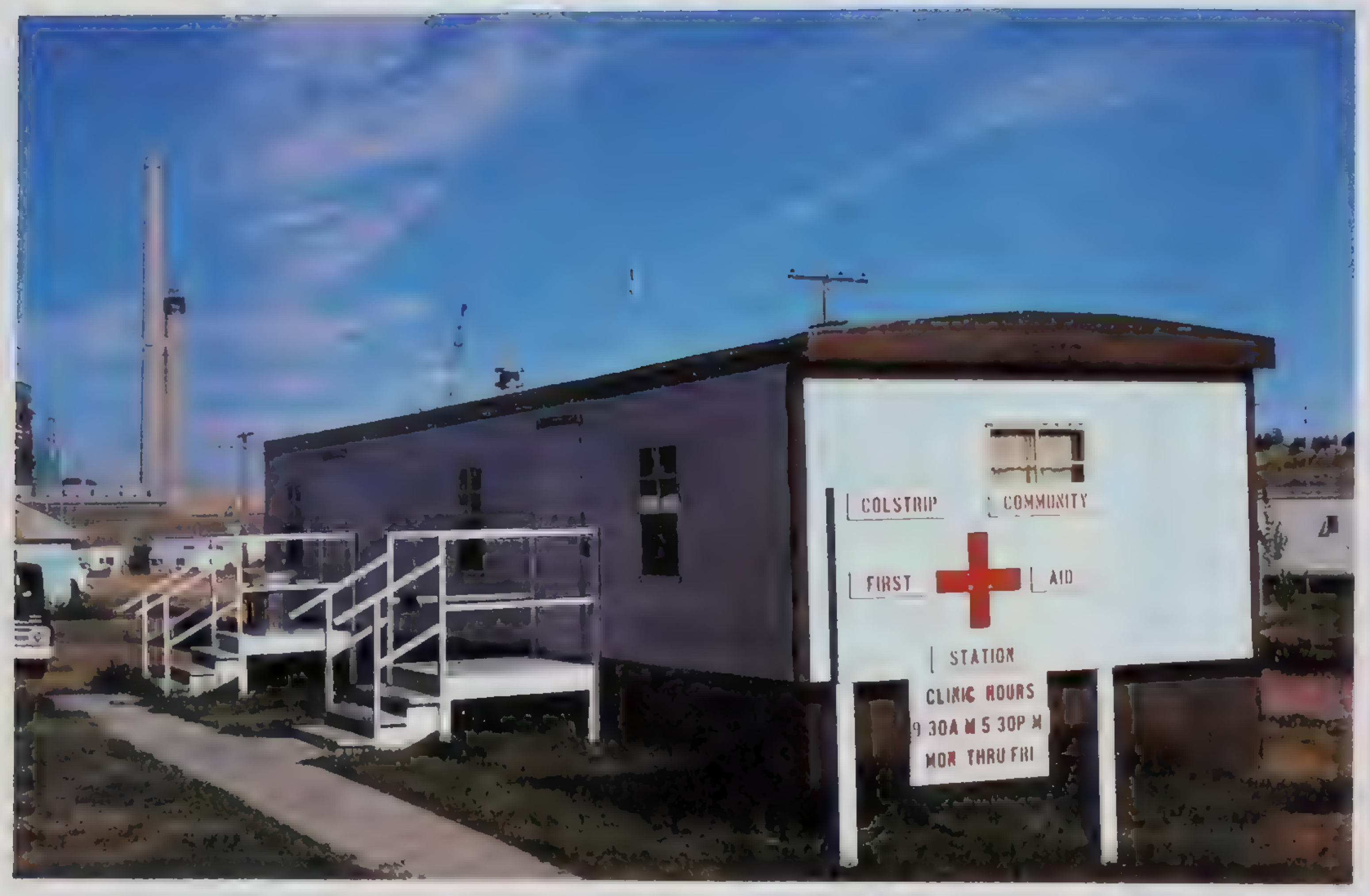


Figure 10-46

Colstrip First Aid Station

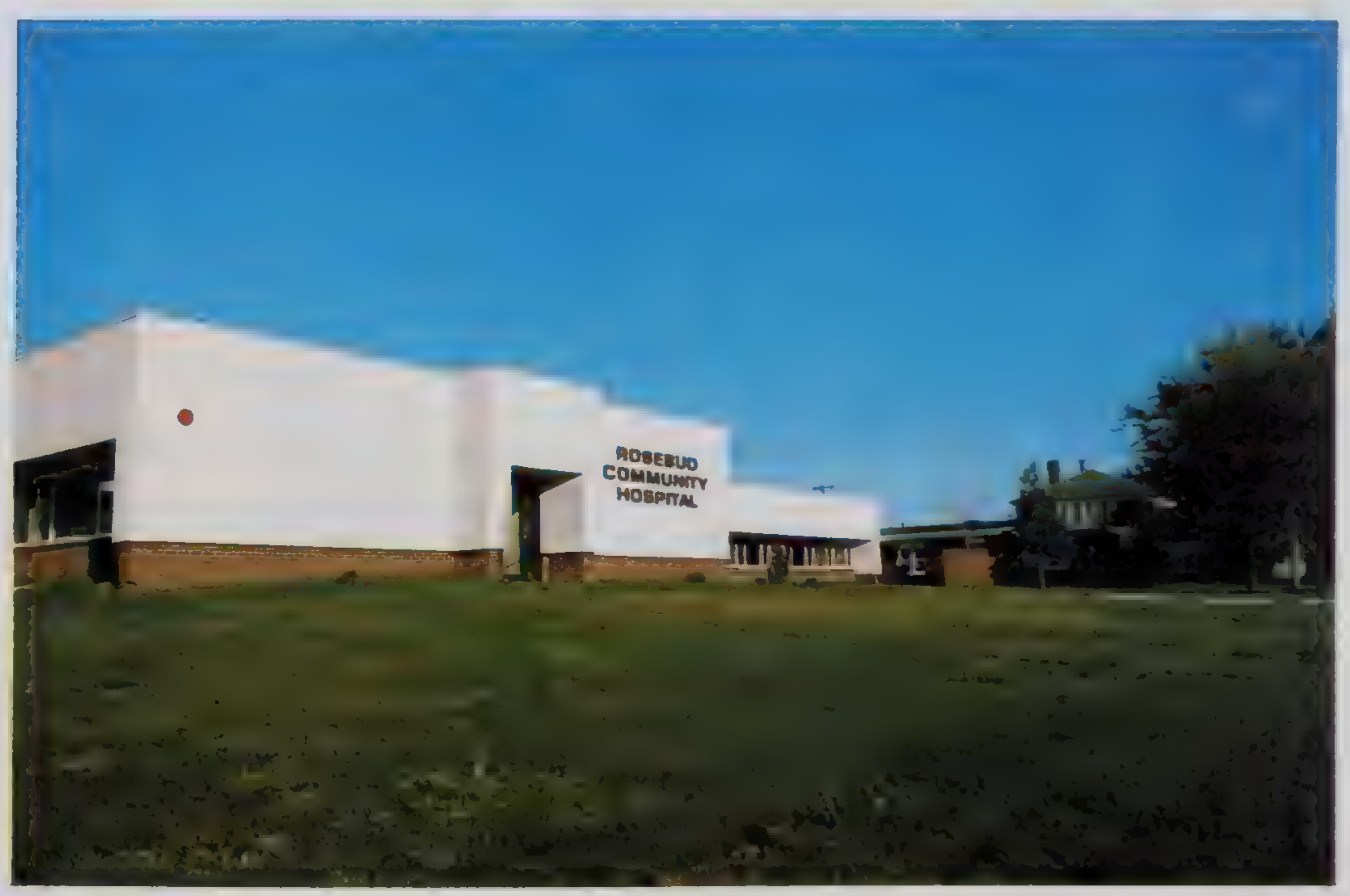


Figure 10-47

Rosebud Community Hospital located in Forsyth week. This medical care situation is inadequate for a community of 2,000 people.

ii. Forsyth

A new 26 bed hospital located in Forsyth provides facilities for the present needs of the city and Rosebud County (see Figure 10-47). The occupancy rate is reported to be about 80% (Leidholt 1974). Coronary and intensive care units have been added recently, and a 20-bed wing can be added to the core facility when it is needed (Leidholt 1974). Although an additional physician recently settled in the community, bringing the total number of M.D.'s in Forsyth to three, this total is still insufficient to handle the medical needs of the county's non-Indian population. The urban population of Forsyth and Colstrip alone (estimated to be 5,000 people at present) should be able to support five physicians according to standards applied elsewhere in the nation. Thus, by far the county's greatest health care need is for skilled nurses and physicians, especially surgeons. Many patients currently prefer to travel to larger hospitals for treatment of even relatively minor ailments. The former Forsyth hospital building has been unused since the new hospital went into service a year ago. Possibly the old building can be used in the future as part of an expanded health care complex. Part of it could conceivably be used as a retirement home.

iii. Lame Deer

At Lame Deer, the Indian Health Service operates an out-patient clinic which is staffed by three nurses, two physicians, and one trained physician's assistant. Hospital patients must be transferred to the Indian Health Service hospital at Crow Agency. As is the case on other Indian reservations, there is frequent turnover among physicians at Lame Deer, and none of the physicians has a long-term commitment to the area; Public Health Service physicians are assigned to both the Lame Deer Clinic and the Crow Agency Hospital for two-year tours of duty. Generally, that time period is not extended, even though the Indian people feel that they no sooner get to know a doctor well enough to know if they can have confidence in him than his tour of duty ends. In contrast to the doctors' pattern of biannual turnover, administrators and nurses remain longer in their jobs. More often now, the nurses and other supporting staff are tribal members. The construction of a new clinic building in Lame Deer is under discussion, with a pending request for federal funds.

b. Ambulance Service

i. Colstrip

A recently rebuilt 1965 Cadillac ambulance owned by the Western Energy Company serves Colstrip. Five Western Energy employees have completed the Emergency Medical Training Program and are on call as driver-attendants. In addition, one of the company-employed nurses from the first-aid station accompanies each ambulance call. The service meets state ambulance service licensing standards and is a licensed service.

ii. Forsyth

One county-owned station wagon-type ambulance housed in Forsyth is maintained to serve all of Rosebud County, with the exception of the

Northern Cheyenne reservation and the company town of Colstrip. On the average, the service responds to two calls per week. A driver with Emergency Medical Training (a standard training program required for state licensing) operates the ambulance, which is equipped with advanced first-aid facilities. However, the service lacks pneumatic equipment (for extraction of auto wreck victims) and a back-up vehicle (although private station wagons have been called out on occasion). The Sheriff's Department provides assistance with accident cases when necessary, although the deputies do not have Emergency Medical Training.

Priority needs are for vehicle housing (presently the ambulance driver is using his personal garage, which he heats at his own expense out of the income he derives from patient charges) and purchase of a larger van type ambulance to supplement and extend the capability of the present service by making available an equipped back-up unit.

Although the county lacks regular air ambulance service, a private plane available for charter service can be used if necessary, since air ambulance service in Montana does not require state licensing.

iii. Lame Deer

The Indian Health Service Clinic in Lame Deer has maintained ambulance units and drivers for transporting patients mainly to the Indian Health Service hospital at Crow Agency, but also for whatever emergency needs arise. Recently, however, the clinic contracted with a state-licensed ambulance service organized by a private group working in coordination with the Tribal Council. All dispatch will be handled through the Tribal Police Department. Nevertheless, the clinic will continue to maintain its own ambulance and driver to handle the transfer of non-emergency cases to the hospital at Crow Agency, the Billings hospitals, or to other state institutions such as those at Warm Springs and Galen.

C. Retirement and Nursing Homes

i. Colstrip

Colstrip area senior citizens needing extended nursing care are served by the nursing wing of the hospital in Forsyth.

ii. Forsyth

A 39-bed nursing home wing is attached to the hospital in Forsyth, thus enabling the hospital staff to be more immediately accessible when needed. For present, this facility is meeting the needs of the elderly population in Forsyth and Rosebud County. However, a retirement home may be needed in the future to enable local citizens to receive this type of care without having to move away from their home area.

iii. Lame Deer

Although by tradition, the needs of elderly Northern Cheyenne people are met within the extended family, a staff member of the Indian Health Service hospital in Crow Agency stated that there are currently some potential retirement and/or nursing home clients living on the reservation. Thus, a small nursing home could possibly be appreciated at Lame Deer. However, such a facility would have to be established by a private group or by the tribe since the Public Health Service does not fund nursing homes.

d. Public Health Nursing and Industrial Nursing

i. Colstrip

The Rosebud County Public Health Nurse makes regular visits to Colstrip, especially to expectant mothers, and seems to be well received and appreciated. However, she has difficulty finding time to attend the needs of the many new residents of the community. Since several towns in Rosebud County will possibly be affected by coal-related population growth, at least one more nurse is needed to adequately serve the county. Meanwhile, two company-employed registered nurses serve both the first-aid unit in Colstrip and Bechtel's first-aid station at the plant site./21

ii. Forsyth

The Rosebud County Public Health Nurse serves all of Rosebud County, including the city of Forsyth. Much of her service involves vision and audio screening, general health checks, and an immunization program in eight elementary and three high schools. Clinic programs in immunization, prenatal care, and nutrition are also provided by this same nurse, on a regular basis. Home visits to senior citizens, expectant mothers, and others are provided as time permits. Although the Public Health Office occasionally has supervised nursing students from MSU School of Nursing, this supplementary help is not sufficient to meet the growing workload.

iii. Lame Deer

The Indian Health Service Clinic in Lame Deer provides one public health nurse, backed up by a licensed practical nurse and a psychiatric nurse (officed in the Mental Health Unit) to serve the Northern Cheyenne Reservation. Well-child, tuberculosis, and venereal disease clinics are held twice monthly in Lame Deer, Busby, and Ashland. Although the present clinic facility is inadequate, the size of the nursing staff is adequate for existing health care needs on the reservation.

A nutrition program, operated in coordination with health care services, includes some visits to Indian residents by a trained nutritionist.

e. Mental Health

i. Colstrip

The federally-funded Eastern Montana Mental Health Center, which serves an eighteen-county area from its headquarters in Miles City, provides one full-time counselor to serve Rosebud County, including Colstrip, from an office in Forsyth. This counselor also visits Powder River and Treasure Counties on a monthly basis. Because the residents of Colstrip have failed to take advantage of the mental health counseling service, and because the outreach worker does not like to actively promote the use of his service (preferring that potential clients seek him out), visits to Colstrip are infrequent. Nevertheless, social researchers studying Colstrip (Section 11.2.2.2.)

have suggested that counseling services to help people adapt to difficult social conditions in Colstrip are needed. Citizens, however, indicate resistance to the idea of seeking help from people who are labeled as mental health workers.

School personnel show concern about increased drug use and general alienation among young people as compared to a few years ago. Staff available for working on this problem are not sufficient to meet the need.

ii. Forsyth

The service provided by the Eastern Montana Mental Health Center needs expanded outreach and counseling capability as well as better integration into the total service delivery system. Especially needed are expanded marriage, recreation, and drug-use counseling. Improved school-related counseling is also needed; adjustment difficulties of newly arrived Colstrip and Forsyth children are compounded by the number of children involved and alienation in the school is a problem. At present, the counselor makes little time available for school-related or group counseling.

iii. Lame Deer

One psychiatric nurse works with the Mental Health Unit officed in the Indian Health Service Clinic at Lame Deer. Family counseling and career guidance especially need to be added to the counseling expertise of the clinic. /22 A general increase in the number of professionally trained Indian counselors would be helpful.

2. Social and Welfare Services

a. County Welfare

i. Colstrip

Like all other residents of the county, the residents of Colstrip are eligible for county and federal welfare assistance. The Rosebud County and Treasure County Welfare Office has reported no special service demands arising from the rapid population growth in Colstrip, probably due to the high rate of job opportunities. Some increases in welfare loads might be expected during the intervals between peak construction periods, before construction resumes or before workers are able to relocate; however, this type of demand has not materialized yet, except during the recent strike when food stamp requests increased markedly.

ii. Forsyth

Five staff members serve the combined Rosebud County and Treasure County Welfare Department, located in Forsyth. Assistance payments have continued at the same level for several years, and the percentage of the population requesting assistance will not increase as the size of the population and available job opportunities expand. The Department has been effective in reducing clients' dependence on welfare, demonstrated by the fact that there are few second-generation welfare recipients. Home visits by the one professional homemaker are seen as an integral part of the Department's program. The homemaker offers companionship and assists the elderly, disabled, and blind with necessary daily chores such as cooking, cleaning, and grocery shopping.

iii. Lame Deer

Five years ago, the Rosebud County and Treasure County Welfare Department established a field office in Lame Deer. This office provides all categories of assistance provided by county welfare agencies in all states, except general relief and child welfare, which are handled by the three staff members of the B.I.A. Welfare Office (the Northern Cheyenne Agency). The four-member staff of the County Welfare Department is adequate at present but not large enough to service a greatly increased population whether that increase be a result of coal development or of internal growth. Two more staff members will be added soon to handle the Food Stamp Program which has now replaced the Commodities Program previously available on all Montana Indian reservations. Approximately 50% of all child welfare cases in Rosebud County involve tribal members, who account for only 30% of total county population. Ancillary services are provided by Emergency Food and Medical Services, Surplus Food Program and WIC, a special food program for women, infants, and children administered through the Indian Health Service Clinic.

b. Special Social Services

i. Colstrip

At present there are very few specialized social services in Colstrip. No day care center is located there and none is planned according to the Colstrip Master Plan. Expansion of a teen center is planned to include an increased variety of recreation programs, as well as a range of auxiliary youth services. Services for the Aging, a subsidiary of Action for Eastern Montana, serves all of Rosebud County and may initiate counseling and senior citizen programs in Colstrip if they are needed by the area residents.

ii. Forsyth

Except for the counseling services offered by the Mental Health Outreach worker and the local Drug and Alcoholism Program, there are no specialized services for young people in Forsyth. Citizens feel that drug and alcohol problems are increasing with the rapid influx of new residents and that the program must be expanded to help deal with these problems.

Some services such as High School Equivalency Classes are available through Action for Eastern Montana, but these are limited at present because of limited local staff time in the county.

Services for the Aging, a pilot project funded by revenue sharing and a county mill levy, provides counseling and transportation and is working to establish a hot lunch Meals-On-Wheels Program for the elderly. A drop-in center for senior citizens has already opened under the auspices of this program.

iii. Lame Deer

Day care services are now available in several Northern Cheyenne communities, including

Lame Deer. Under the auspices of the Community Action Program, an experimental group foster home for teenagers was established recently in Lame Deer. The Extension Service Agent in Lame Deer is presently very active in generating services and educational programs for young people—especially 4-H clubs and classes. A senior citizen center, located in Lame Deer, provides activities for elderly tribal members on the reservation.

The Welfare Office of the Northern Cheyenne Agency provides general relief, protection from neglect for children, placement in foster homes for young people, and housekeeping services. In addition, Montana's Yellowstone-Big Horn Child Abuse and Neglect Service Project plans to administer a child-abuse and child-neglect service system designed to extend to rural areas support services which have previously been restricted to urban areas. However, a neglect service protection system for Indian children must be tailored to the reservation situation. State laws permitting enforced removal of a child from a neglected situation do not pertain to a reservation, and therefore, parental consent is necessary before an Indian child on a reservation may be removed from his or her home. Thus, protection from neglect cannot be extended in as predictable a manner as it may off the reservation.

3. Fire Protection

a. Colstrip

As is the case in most incorporated municipalities, the Colstrip fire unit is principally for fighting fires in the town. Although the unit did leave town to help with a nearby ranch fire on one occasion in the past, rural fire protection service in the Colstrip area, as in the rest of the county, is provided by the Rosebud County Sheriff's Department. The town utilizes a 1938 Chevrolet Fire Truck owned by Western Energy and which is manned by a fire-fighting force of 12 company employees. The size of the force is adequate compared to that of volunteer forces in similarly sized cities; for example, Hardin has 15 firefighters and Forsyth, a 17-member volunteer corps.

The Colstrip fire truck has a 350-gallon tank (for use in those locations outside of the area where hydrants are installed), 500 feet of discharge hose, 20 feet of suction hose (for use in a pond or watertank), and a pump with a flow capacity of 500 gallons per minute. In contrast, Forsyth, with a similar population level, has a new fire truck with a 1000-gallon tank. A heated garage owned by the company is used to house the fire equipment and should be adequate until the new fire station included in the Colstrip Master Plan is built. Also adequate for present town needs is the existing hydrant system. As the town grows, the system is being extended to adequately cover the requirements of new residential areas. However, Colstrip will need a new enunciator (which enables the firemen to know the location of each fire) on the alarm system to accommodate many new alarm boxes in new residential neighborhoods and other new community facilities. Colstrip does not have a fire rating at present as the town is self-insured.

Even though the State Fire Marshall has no jurisdiction to require MPC to fund adequate fire fighting facilities for Colstrip, conditions there have been reviewed by the Supervisor of the Fire Prevention and Inspection Section. He reports that, in his judgement, several deficiencies exist: (1) the volunteer firemen are not trained well enough (even though the opportunity to use the fire fighters training program offered by the State Department of Public Instruction has been offered, no advantage of this opportunity has been taken); (2) some fire hydrants in the community are facing the wrong direction so that, in the event of a fire, they would be difficult to use; (3) the fire department has limited equipment for forcible entry into a location where a fire is occurring and for pulling down walls or ceilings to gain access to a fire inside; (4) the department lacks breathing masks enabling firemen to enter a smoke-filled location and asbestos suits which would enable firemen to enter hot buildings, and finally (5) the fire department needs a newer truck capable of pumping at least 750 gallons per minute (Roat 1974). /23

b. Forsyth

The city of Forsyth recently purchased a new fire engine with a tank capacity of 1,000 gallons, supplementing an older truck with a 750-gallon tank. The 17-member city volunteer force is well-trained and organized. With a present fire rating of seven, the city is working toward a rating of six, which it should receive when the water storage supply is increased as planned. /24 Although the Rosebud County Fire Department is located in Forsyth, the equipment is used to service the rural areas of the county (see Figure 10-48). With the Sheriff's Department as a voluntary force, the county fire unit has one Army Surplus 6 x 6 truck with a 2000-gallon tank and one 1935 LaFrance fire truck with a 500-gallon tank plus the use of three county spray trucks. As the Sheriff's Department becomes increasingly burdened with law enforcement responsibilities associated with the growing population, the need to create a separate rural volunteer fire department will become more and more apparent.

c. Lame Deer

The Lame Deer Volunteer Fire Department has an old truck with a 250-gallon tank capacity, a tank truck with a 1,500-gallon capacity but no pumping capability, and 800 feet of 2½" hose. The town hydrant system is in good condition. Twenty volunteers, most of whom are BIA employees, train once a week. A fire station and two new fire trucks are needed to make fire protection adequate for the town. The Forest Service gives aid with forest and grass fires on the reservation.

4. Law Enforcement Services

a. Colstrip

The Rosebud County Sheriff's Department will continue to have responsibility for police protection in Colstrip and throughout the county. At present, one deputy is stationed in Colstrip, although the county commissioners recently approved funds to provide a second deputy there. According to national averages, which for purposes of this report have been used as an adequacy standard, a town the size of Colstrip should have four law officers./25 Since Colstrip is on private property, the Sheriff's Office has no authority to enforce general traffic

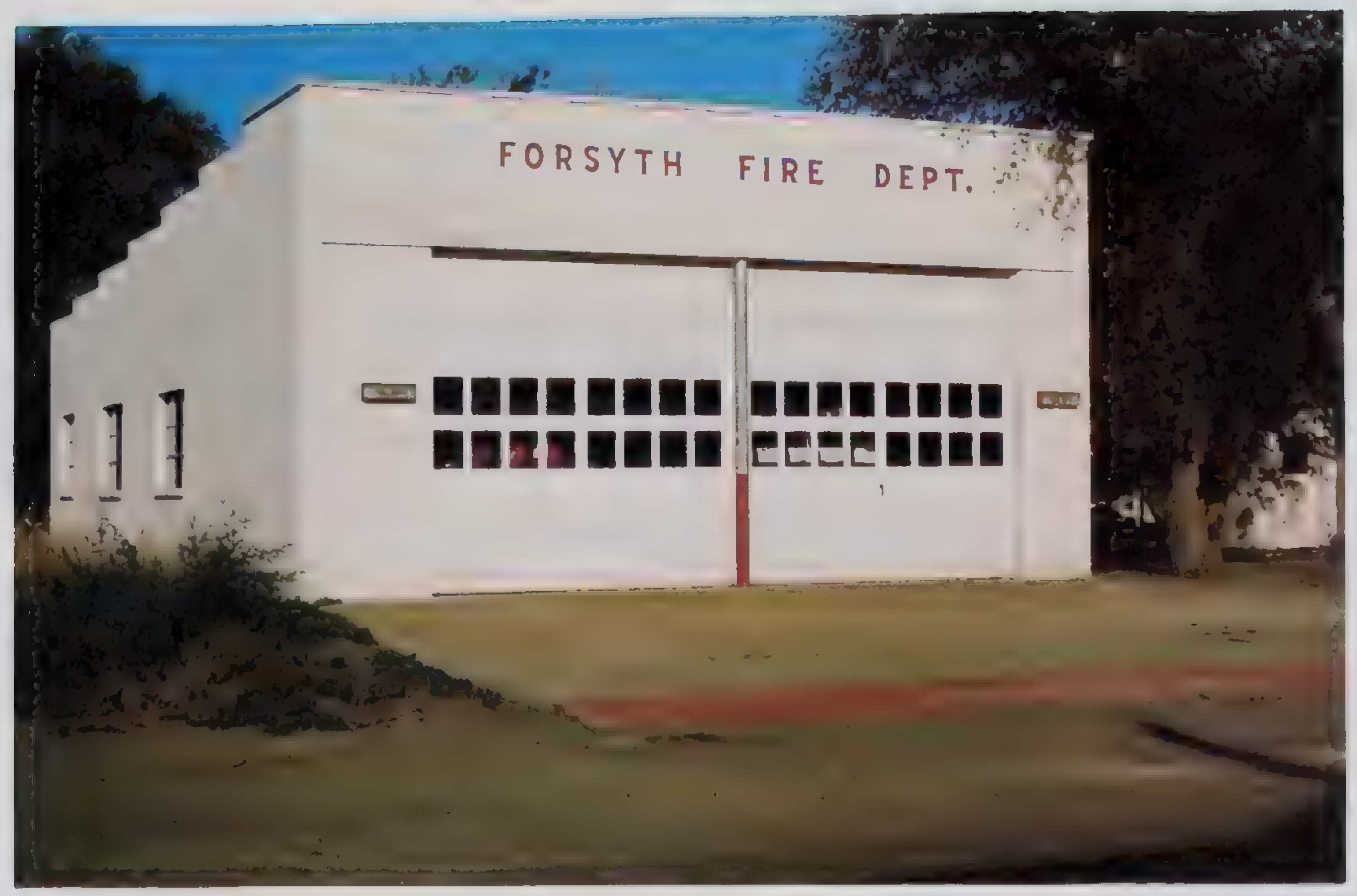


Figure 10-48

Forsyth Fire
Department

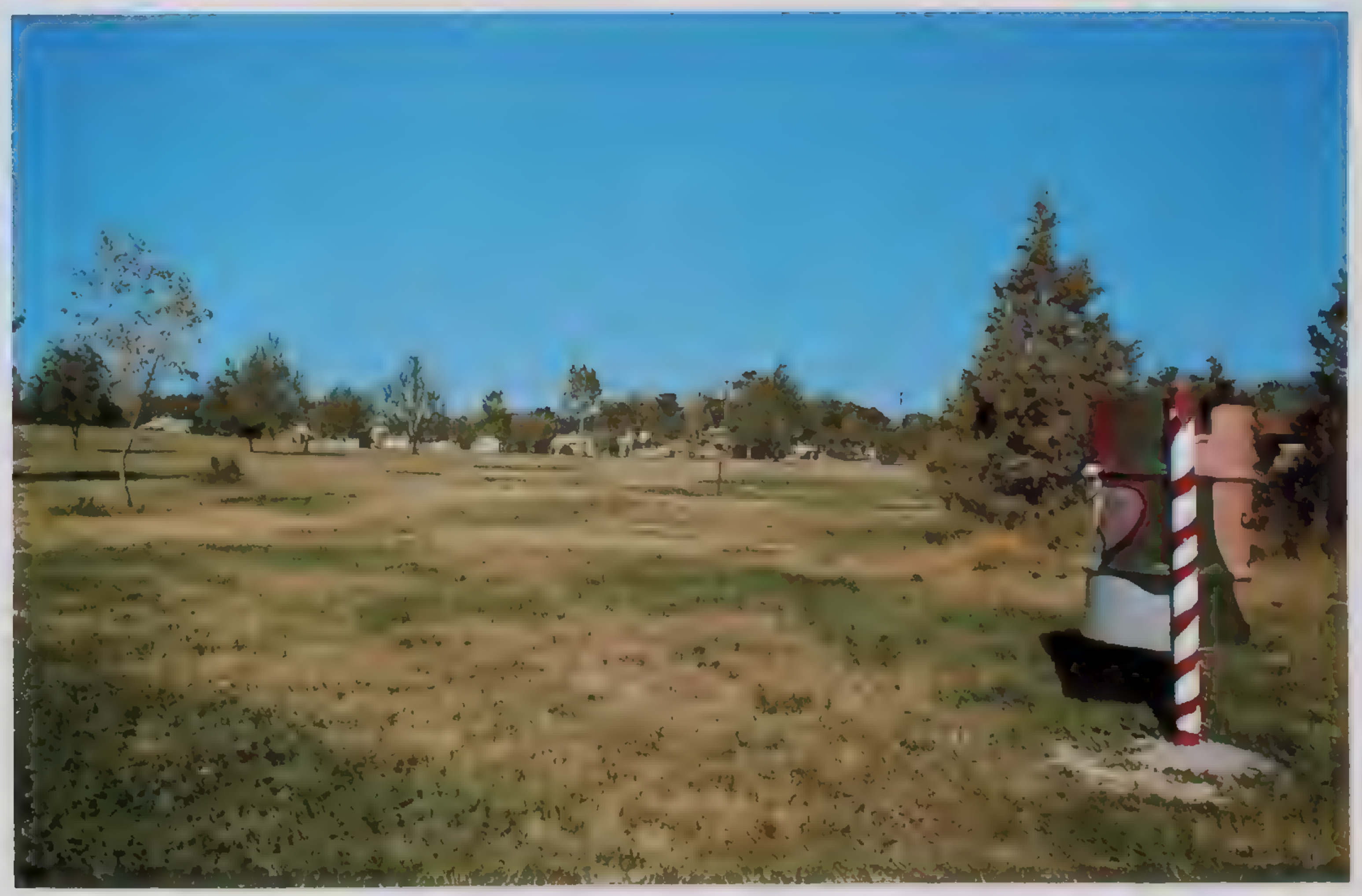


Figure 10-49

Colstrip Town
Park

regulations unless reckless endangering of life and property can be charged. As a result, traffic control, especially of motor bikes, has become a great problem. To ameliorate the situation at least temporarily, MPC is considering, among other alternatives, hiring a traffic officer to enforce company-imposed regulations; this action would be an alternative to the county's suggestion that town streets be dedicated to the county. Upon completion of a new office complex, part of Western Energy's present office will be used as a police station for Colstrip as well as a relay station for radio communications to the southern end of the county.

b. Forsyth

Rosebud County is served by a combined city-county law enforcement department. The ten-member department is headquartered in Forsyth (the county seat), with two deputies stationed in Colstrip, one in Ashland, and one in Birney./26 Police services in Forsyth are provided through a contract with the Sheriff's Department. At present four deputies are serving the city, an adequate number for the population, given the back-up capability of the Sheriff's force. The jail facility built in 1914 is in good condition, but the sheriff suggests a new office be located adjacent to the jail building to improve operating efficiency. County and city deputies recently received a badly needed increase in salary and car mileage reimbursement rates; however, the sheriff predicts a need to double the budget within the next few years. The two Highway Patrolmen assigned to Rosebud County spend most of their working time patrolling the interstate highway.

c. Lame Deer

An 11-member tribal police force stationed in Lame Deer has responsibility for the entire reservation. However, the department Captain feels that to provide fully adequate service a still larger force is needed. At present, the tribal police have jurisdiction only over Indian people although non-Indians may be detained until it is possible to transport them to authorities off the reservation or until the Sheriff's Department can be summoned to take responsibility. Cross deputization with Rosebud and Big Horn County Sheriff's Departments is needed more because of problems caused by transient non-Indians than by resident non-Indians. The six patrol cars and one pick-up truck are all radio-equipped and in good condition. Tribal police officers are now receiving needed wage increases but do not have a personnel benefits program. Other services provided by the department include provision of volunteers for the fire department and radio dispatch for emergency medical vehicles. As of July 1, 1974, the force received a 25% budget increase from the tribal council.

5. Public Transportation, Highways Roads and Streets

a. Colstrip

Operating on a Public Service Commission permit, a commuter bus has recently started providing daily service between Forsyth and Colstrip. A planned similar commuter bus to provide service from Lame Deer to Colstrip has not materialized thus far. While streets within the town of Colstrip are not in excellent condition at present, an extensive paving program is scheduled to proceed as new residential neighborhoods are completed. Concrete curbs, gutters, and sidewalks are planned for all of these neighborhoods.

Daily Amtrak east and west train service, and greyhound east-west bus service provides the residents of Forsyth with more adequate travel opportunities than residents of many Montana towns enjoy.

b. Forsyth

Some city streets in Forsyth presently need paving, although perhaps the biggest shortcoming of the Forsyth street system is its lack of storm drains. At present, water standing in pools after a rain storm or after a winter thaw causes cracking and general deterioration of the street surface, resulting in increased maintenance costs. Although the county road department could provide better maintenance of the network of dirt roads if it had some additional upgrading equipment, unpaved rural roads are not below standards of other sparsely populated counties. Since the department was recently relieved of responsbility for roads on the reservation, it can now more easily cover the rest of the county.

c. Lame Deer

The Bureau of Indian Affairs Roads Office now maintains all roads on the reservation, after recently assuming responsibility for some roads previously maintained by Rosebud County. Four year-round maintenance workers are employed, and in addition, 20 to 25 workers are hired during the summer construction season. A plan to start a street paving project in Lame Deer should solve the serious problem of dust and mud within the town. Construction of sidewalks, also needed in the town, is not yet scheduled. Daily van service, which can accomodate a few passengers along with the mail, is available through Lame Deer to and from Hardin and Billings.

6. Municipal Services

a. Colstrip

Once the pipeline bringing cooling water to Colstrip Units 1 and 2 is completed, 1,050 gallons per minute of that water will be set aside for urban use in Colstrip. A new treatment plant, planned for completion by November 1974, is designed to chlorinate and filter this water for urban use. With the population projected to stabilize at approximately 2,000 residents upon completion of Units 1 and 2 (without further growth resulting from construction of Units 3 and 4), Colstrip will need 1,035,000 gallons of treated water per day./28 The present well system's 504,000 gallons per day is entirely insufficient, falling short by 50% of the required amount. The new water treatment plant will process 1,512,000 gallons per day and thus is capable of serving a maximum population of 3,000. At present, water is derived from three company-owned wells, the most productive of which provides 200 gallons per minute. The water from this 9600-footdeep well reaches the surface at 210°F and is cooled before it is treated and stored. Water from this well will also be used to provide heated water to a swimming pool which will soon be under construction. Water from the other wells is of sufficient purity not to require treatment prior to use.

Water storage facilities consist of three tanks of 100, 500 and 110 thousand gallon capacity, respectively, with a total storage capability of 710,000, which is an adequate amount for a town of 2,000 residents. However, several variables must be taken into account when considering the water storage needs of Colstrip. First, if generating Units 3 and 4 are constructed, the population of the town is projected to increase by 1,350 to 3,350 residents (see section 11.2.2.1.). Towns of similar size, Hardin and Forsyth, have planned water storage capacities of 1,000,000 and 1,330,000, respectively, which suggests that Colstrip would have to increase its water storage facilities capacity by at least 300,000 gallons. Secondly, the 110,000 gallon tank is an underground tank made of concrete and may be irreparably damaged by blasting activity when mining starts nearby. Lastly, though adequate for normal daily usage, the present water storage facilities may not be adequate for fire flow requirements. It is calculated that if water is consumed at a peak summer daily usage rate of 862.4 gallons per minute and if at the same time a fire were to necessitate pumping at the maximum capacity (500 gallons per minute or 30,000 gallons per hour), the storage tanks would be depleted in approximately eight hours./29 This is less than the present fire flow capacity of the Forsyth system, which because of its present inadequacy is being improved.

A 10.56-acre lagoon-type sewage treatment facility consisting of three cells (4.46, 3.84, and 2.26 acres) is adequately handling the present sewage load due to a special circumstance. To make sure that existing sewage flow does not exceed lagoon capacity, water is being trucked from the lagoon for use in earth compaction at the site of the reservoir presently under construction nearby (to hold the water being piped from the Yellowstone River). Thus, it is impossible to estimate how much of Colstrip's current sewage flow could be effectively handled by the lagoon system. The adequacy standard of one acre of lagoon per 100 people on the system (HES 1974), suggests that Colstrip presently needs to double its present lagoon capacity. Therefore, a fourth cell is under consideration. The present system was funded approximately 25% by MPC, which also assumes all maintenance costs and approximately 75% by the EPA. However, instead of enlarging the lagoons in the future. Western Energy Officials are also considering use of an alternative system requiring less lagoon area. Under this system, raw sewage would be pumped to a series of aerated lagoons and chlorinated. The treated effluent would then be sprayed as liquid fertilizer on lands being reclaimed after strip mining. The soil-plant complex would act as a filter to remove the bulk of nutrients, to trap pathogenic bacteria, and to remove other contaminants. Having received the equivalent of tertiary sewage treatment (otherwize necessitating more lagoon acreage), the filtered water would then be removed through an extensive system of burned drains to be discharged to the headwaters of local streams (Chaiken et al. 1973).

Colstrip's previous twice-weekly garbage collection service has been curtailed due to the rapid influx of new residents; the service now is irregular. Another truck and two more operators are needed to make the service adequate for the town.

b. Forsyth

Forsyth's existing municipal water system has been adequate in the past, but is now operating at full capacity. Since it is impossible to repair the antiquated treatment plant any further, it must now be fully overhauled and modernized (Morrison-Maierle Inc.1972). The present plant capacity of 1.5 million gallons per day should be increased to a minimum of 3.0 million gallons per day in order for the system to produce the necessary 2,000 gallons per minute flow rate (Morrison-Maierle Inc. 1972)./30 Also, 14-inch water mains are needed to replace the 40-year-old 10-inch cast iron mains which transport water from the collection well at the Yellowstone River to the treatment plant and from the plant to the distribution system. In addition, the existing 4-inch water mains in the present distribution system cannot provide even flow to all parts of the growing town. (A minimum 6" diameter pipe is now necessary—Morrison-Maierle Inc. 1972.)

A pre-1918 concrete storage reservoir is in good condition and is well placed with respect to the water treatment plant and distribution system. However, its 330,000-gallon capacity is totally inadequate for peak day use and fire fighting flow requirements; therefore, the plan prepared by the Morrison-Maierle consulting firm recommends that a new steel reservoir, with a capacity of 1,000,000 gallons be added to the city water system. The 10-hour fire flow capacity of the present system is calculated to be 850 gallons per minute. This rate is 1,650 gallons per minute short of the minimum fire flow recommended by the Insurance Services Office of Montana. Water rates in effect since December 1961, will be inadequate to finance the needed improvements and will have to be increased.

Forsyth has a two-cell lagoon system with a total of eight acres, which is inadequate according to the standard of one acre per 100 people. Hence, the EPA has recommended more lagoon area. In addition, the effluent from the system does not meet state health standards (HES 1974). Forsyth's discharged water is yielding a bacterial count of 25,000 colonies of coliform bacteria per 100 milliliters of water, whereas by state standards the effluent must be below 200 colonies per 100 milliliters of water. Also, an 85% removal of biological oxygen demand in raw sewage is required. At present the Forsyth sewage system is only removing 60%. Inasmuch as the discharged water is not being treated sufficiently by natural lagoon processes, it needs further chlorination.

With the recent purchase of a new truck, garbage collection services are now adequate and regular in Forsyth, Twice-weekly collection for residents costs $24.00 per year, and daily collection for businesses costs a minimum of $54.00 per year. However, the city's public works director anticipates that the city will have to either hire two more operators to operate the old truck, which is not now in service but stands ready, or cut back services if town population continues to grow. A new landfill dump, sufficient for present needs, is financed by city taxes and is open to all residents without charge.

c. Lame Deer

The Northern Cheyenne Utilities Commission, in cooperation with the B.I.A., manages all utilities on the reservation. Water from three relatively shallow wells, each producing 45 gallons per minute, provides a sufficient flow of water to adequately serve the town's population. However, the commission is concerned that strip mining activity in the neighborhood could interrupt the water flow in these wells. In addition, another well and pump would be necessary if a high school were built in the area. At present, water from the wells tests pure and requires no treatment. The water reservoir has a storage capacity of 400,000 gallons, which is barely adequate to meet the needs of the present town population. Current sewage needs are being met by a ten-acre lagoon. A land-fill dump is open to the public and maintained by the Indian Action Team as part of their bulldozer operation training program.

Lame Deer residents contract with a private garbage collection service; the two trucks of this service are adequately meeting the town's needs.

7. Schools

a. Colstrip

According to the 1973-1974 Montana Education Directory, Colstrip's elementary school served 178 students, and its high school 162 students, as of October 1, 1973 (see Figure 10-50). However, due to continuing population turnover as stages of the construction work on Units 1 and 2 were begun and in some cases completed, classroom enrollment fluctuated and showed an overall increase throughout the past year.

In order to accommodate the rapid growth in school-age population, temporary facilities have been necessary; four modular classroom units and a double shift were used during the 1973-1974 school year (see Figure 10-51). Although provision of additional school facilities is a public function, MPC had financed the mobile classroom units, with the school district financing equipment and books.

Some Rosebud County taxpayers have said that MPC should build a new school building at Colstrip to better accommodate the student population. So far, the company has refused on the grounds that larger facilities will not be needed when construction is completed. The present school site can accommodate additional buildings, including any additional playgrounds and athletic fields that may be required. In its land use plan, the company has set aside additional property adjoining the present school site for future school use.

b. Forsyth

The Forsyth School District is one of eight separate districts in Rosebud County (see Figure 10-52); however, only the Forsyth, Rosebud, and Colstrip districts include high schools. During the 1973-1974 school year, the Forsyth Elementary School experienced an 11% increase in student enrollment, while the high school's enrollment increased 19%. Even with these recent increases,

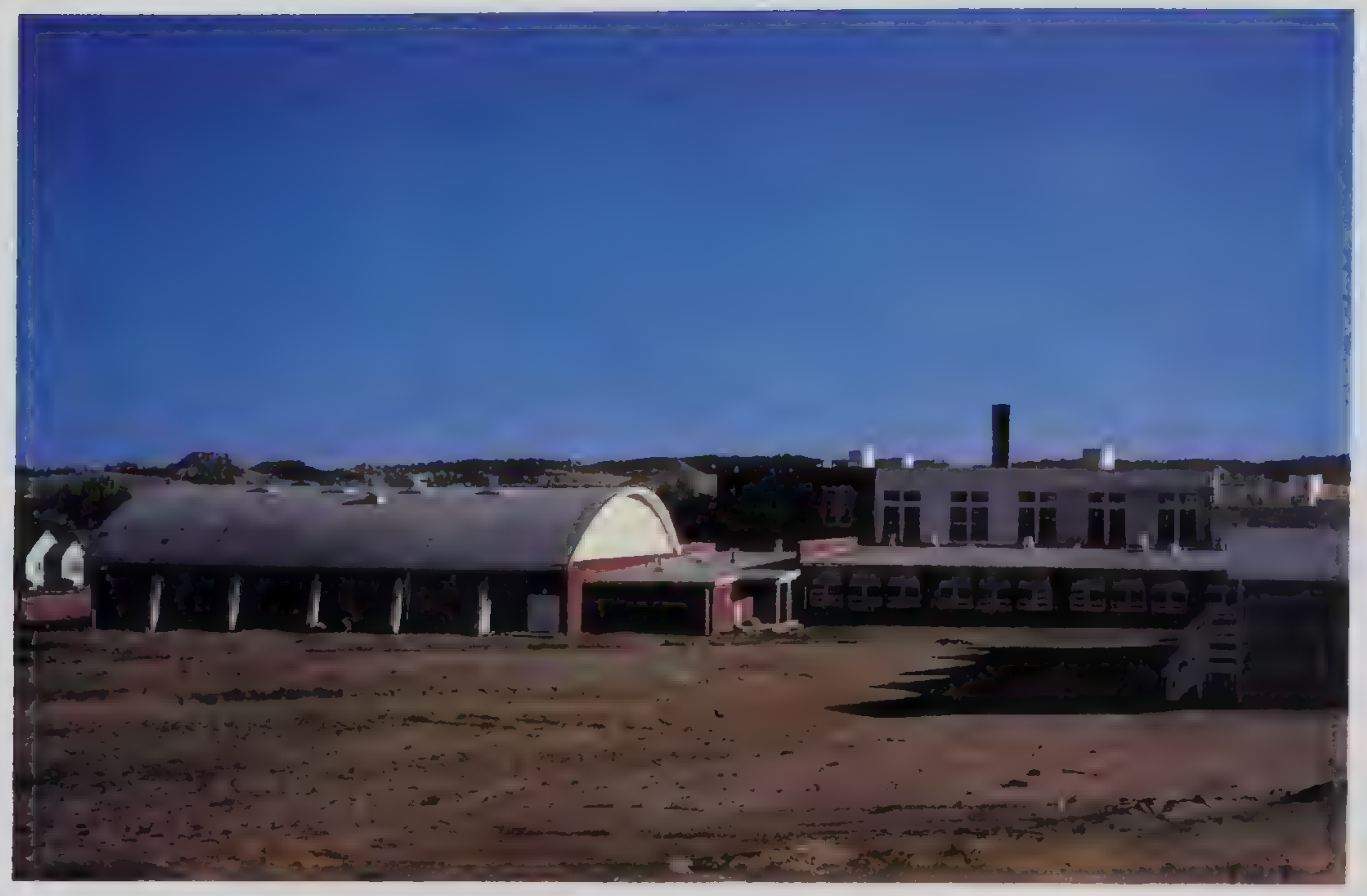
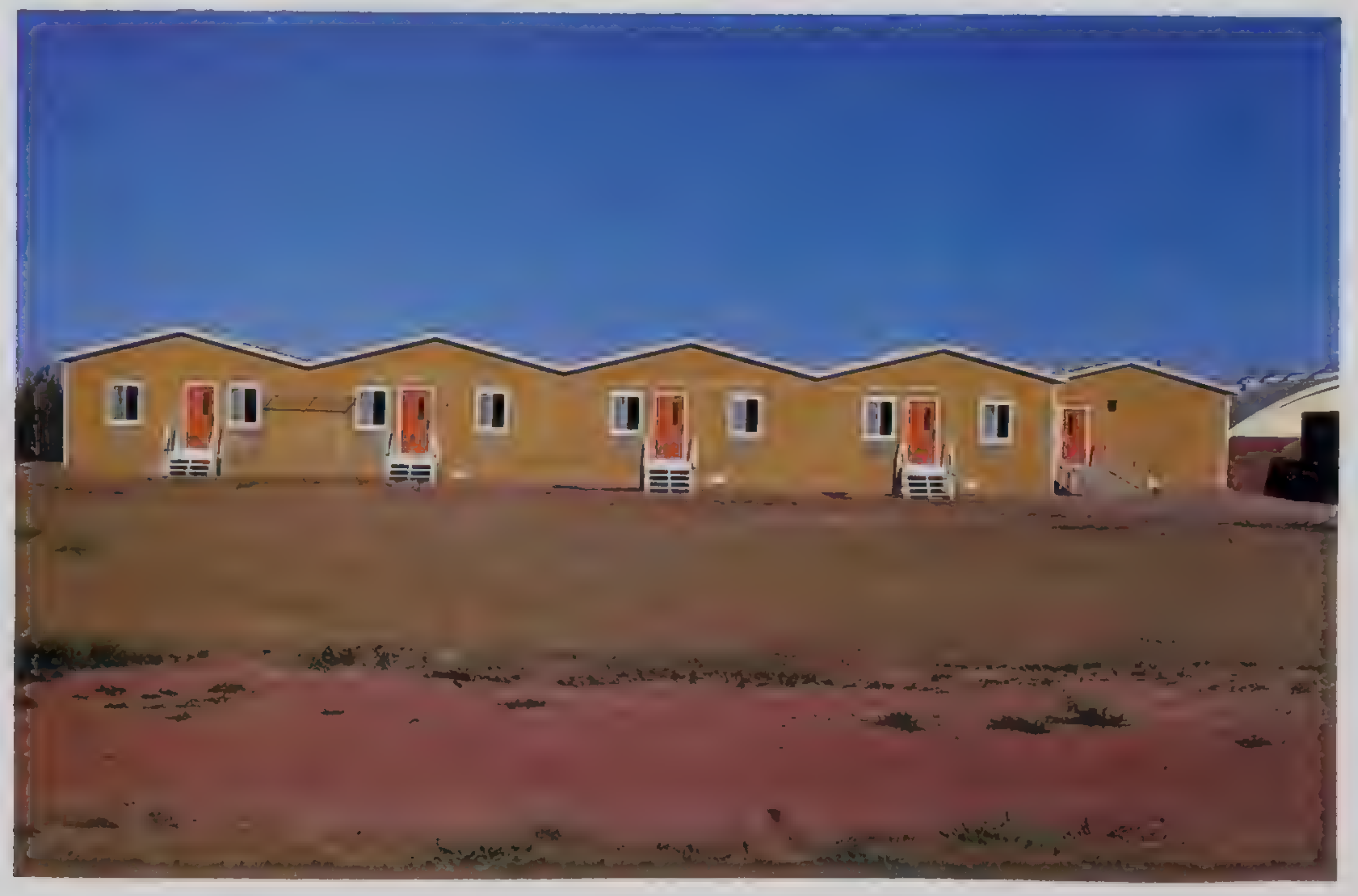


Figure 10-50

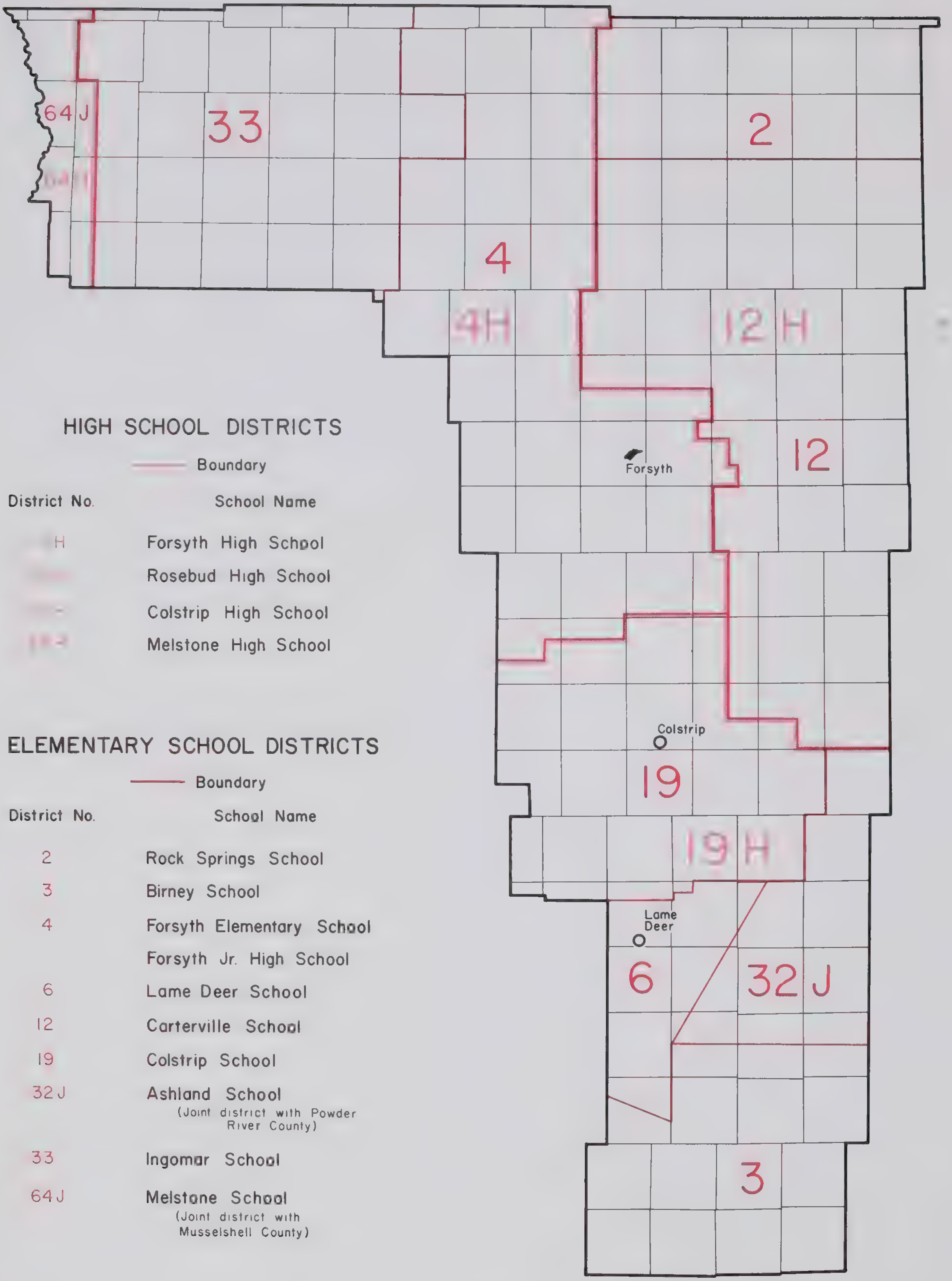
Colstrip High
School

Figure 10-51

Modular Units added
to the Colstrip
High School



ROSEBUD COUNTY SCHOOL DISTRICTS



HIGH SCHOOL DISTRICTS

Boundary

District No.	School Name
H	Forsyth High School
[illegible]	Rosebud High School
[illegible]	Colstrip High School
[illegible]	Melstone High School

ELEMENTARY SCHOOL DISTRICTS

Boundary

District No.	School Name
2	Rock Springs School
3	Birney School
4	Forsyth Elementary School
	Forsyth Jr. High School
6	Lame Deer School
12	Carterville School
19	Colstrip School
32 J	Ashland School (Joint district with Powder River County)
33	Ingomar School
64 J	Melstone School (Joint district with Musselshell County)

FIGURE 10-52

the Forsyth schools were operating below capacity with space to accommodate increased enrollment. As of February 1974, the elementary school had 335 students with a capacity for 503; the junior high school had 112 students with a capacity for 150; and the high school had 210 students with a capacity for 280. However, if in 1973 the Forsyth school system had not been able to lease an unused Catholic school to serve as a junior high school, the elementary and senior high schools would have had to absorb all 112 junior high students. The school system would have been operating with 186 fewer student spaces and would have been severely strained by recent population growth. All school facilities are in moderately good condition for the time being. Older facilities should be remodeled or replaced, but not until longer term population growth patterns become clarified. In anticipation of continued job availability at Colstrip, the Forsyth High School is upgrading its Vo-Tech offering. At present the Forsyth school system does not offer any adult education opportunities.

c. Lame Deer

The elementary school at Lame Deer, like all the other elementary schools in Rosebud County, has its own school board and district. This is the only public school in Lame Deer, although two privately operated schools on the reservation serve reservation young people of both elementary and high school age. One is the Busby School now operated by the tribe. The other is the St. Labre Mission School near Ashland which is affiliated with the Catholic Church. Both schools have boarding facilities and also use buses to transport students. A bus from St. Labre transports students from Lame Deer and Birney Village daily. As of October 1, 1973, according to the 1973-1974 Montana Education Directory, 342 students were enrolled in the Lame Deer Elementary School. Public high school students commute to Colstrip since no public facility is available in Lame Deer. However, the tribe has been attempting for a long time to have a public high school built on the reservation. Possibly the need for expansion of the Colstrip school offers an opportunity to reconsider this long-standing desire of the tribe for its own high school. During some years in the past, half of the students in the Colstrip High School have been from the reservation. If these students had a new high school of their own at Lame Deer, some of the present pressure on Colstrip school facilities could be relieved. A Headstart program at Lame Deer is staffed with well trained teachers. Follow-Through, a supplementary post-Headstart program, also has a program at Lame Deer to help low income minority children overcome cultural handicaps. Unless alternative funding is found, however, the program will be phased out in 1975.

8. Recreation Facilities

a. Colstrip

Colstrip will soon be hiring a full-time recreation director, authorized and paid by MPC. Assisted by a summer recreation aide, the director will work with an elected Recreational Committee to plan and implement all organized recreational activities at Colstrip. Construction of a new community center is planned to begin after officials of MPC decide upon the specific facilities to be included. The Kiwanis Club is sponsoring a fund-raising effort to build an AAU standard-size swimming pool. Construction will start soon. Construction companies and suppliers of material for Units 1 and 2 have been major contributors to this project. Six tot lots and six basketball courts have been included in the Colstrip Master Plan, and two of each have been completed this year. Construction of the community tennis courts has been postponed until next year, but the baseball-football field complex is already under construction and nearing completion. Contiguous to the baseball field is a park with picnic areas. A bicycle path is being constructed which will weave its way through the parks and residential areas of town without crossing any paved roads. Underpasses are being constructed to route the path under town streets. In addition to the recreational areas for organized activities, several open playfields will be developed. A golf course and community recreation area are planned for areas outside the immediate townsite. The settling pond for industrial water from the Yellowstone River will be designed for recreational use, although motor-powered boats will be excluded. Completion of everything in the Colstrip Master Plan is scheduled for 1977, at which time company officials feel the residents of Colstrip will enjoy comprehensive recreational opportunities. Figure 10-49 is a photograph of the existing Colstrip town park, and Table 10-81 lists the standards for park and recreation facilities at Colstrip.

b. Forsyth

Most publicly available recreation facilities in Forsyth are in Riverside Park near the center of town, although two state parks, the county fairgrounds and a variety of other facilities are close by. A municipal pool in Riverside Park offers free swimming to residents in the summer; the city is trying to obtain a Bureau of Outdoor Recreation grant to provide the estimated $107,000 needed to construct a new pool and bath house./31 The present facilities are rundown. Also, tennis courts in the city badly need resurfacing. Riverside Park also has other facilities including a ball park and a football field. Outside of town is a private golf course with grass greens (which is becoming a major social center for the community) and a rifle range. The two state parks are within driving distance and provide picnic areas, boat docks, and sufficient expanse of river to permit water skiing. Nevertheless, more playing fields and a recreation center for teenagers are badly needed in Forsyth.

c. Lame Deer

Recreational facilities at Lame Deer include an outdoor swimming pool for summer use, a tribal gym used for sports and dances and as an assembly hall for meetings and other purposes, a hand game building used for games and social gatherings, and the Pow Wow Grounds south of town. Swimming, camping, and picnicking are available at Crazy Head Springs, approximately ten miles east of Lame Deer. The Ice Wells, nearby, and Lookout Point are also used by local people for picnicking. A recreation and tourism program created and funded by the Northern Cheyenne Tribal Council sponsors a variety of activities, mainly for tourists.

TABLE 10-81

STANDARDS FOR PARK AND RECREATION FACILITIES
COLSTRIP, MONTANA

Type	Activities	Size	Area (incl. buffer space)	Recommended Equipment
Playfield	Open area for field games:		160,000 sq. ft.	
	football	160'x360'		goals
	baseball	400'x400'		backstops, bases, pitcher mound
Developed Park	Landscaped area for passive activities	variable	variable	shade trees, seating, picnic tables, outdoor cooking facilities, walkways
Tot Lots	Areas with play equipment for small & large children		1/4 acre minimum	slides, swings, climbing equipment, play sculpture, merry-go-round, tetter-totter
Open Parks	Landscaped areas for unstructured activities	variable	variable	shade trees, flower gardens, walkways, seating, open areas
Teen and Community Center	Indoor and outdoor recreation, craft & activity facilities for various age groups	variable	variable	general multi-purpose space activity and craft rooms, kitchen facilities, game room, outdoor space for court games, swimming pool

TABLE 10-81 (cont.)

STANDARDS FOR PARK AND RECREATION FACILITIES
COLSTRIP, MONTANA

Type	Activities	Size	Area (incl. buffer space)	Recommended Equipment
Bicycle Paths	Bicycle & pedestrian circulation separated from automobile traffic	6' width minmum	variable	hard surfaced pavement with 12-inch shoulders. Bicycle stands at major activity areas

Ken R. White Company 1972

9. Planning

a. Colstrip

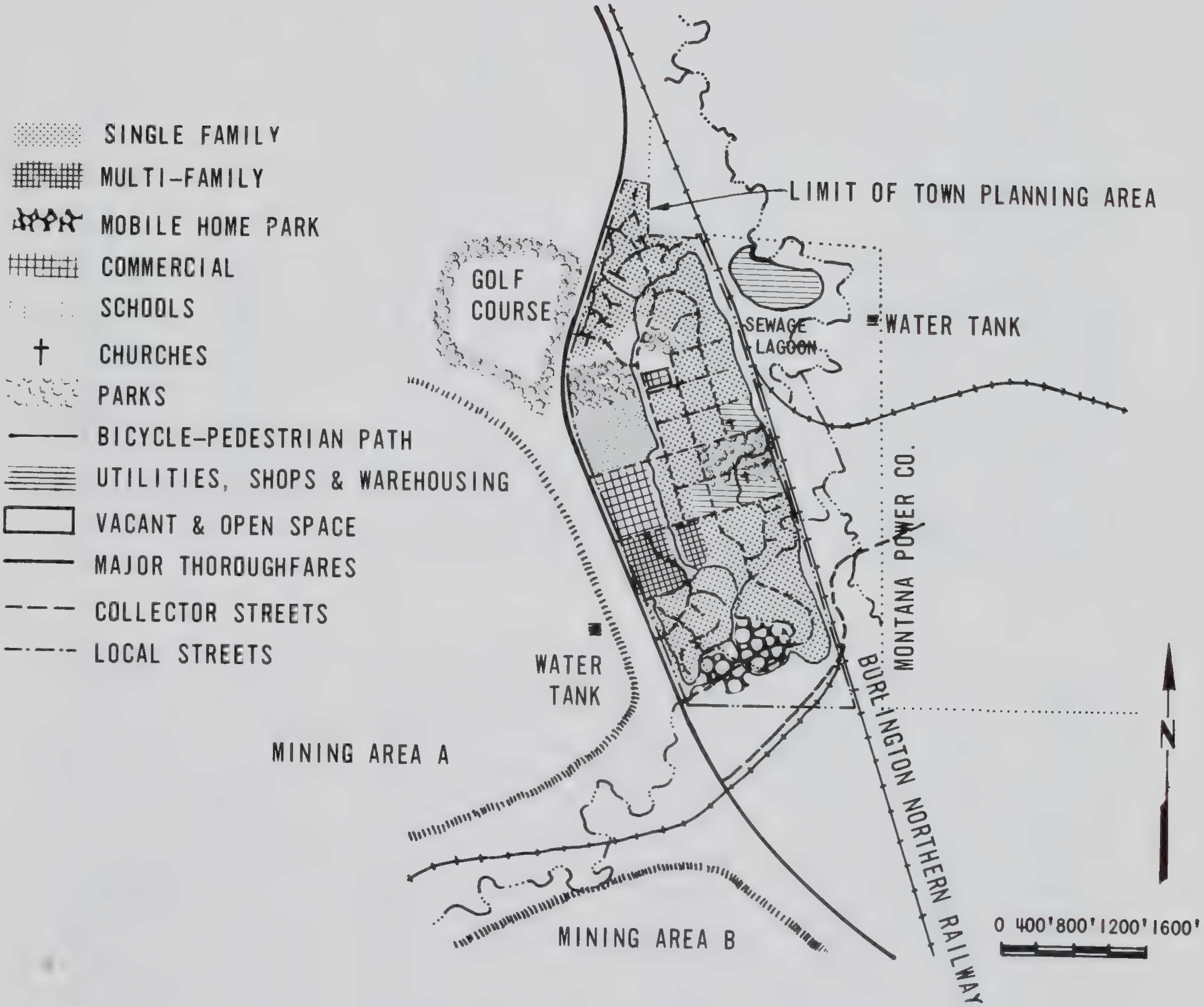
A master plan for the development of the Colstrip townsite (Figure 10-53) has been prepared by the Ken R. White Company, a consulting firm located in Denver. The objective of the plan is to provide for orderly development of the town of Colstrip, thereby benefiting the Western Energy Company by minimizing economic inefficiencies and enhancing public relations and employee satisfaction. By avoiding the image of a "company town," Western Energy hopes to establish a "model" community with good educational and recreational opportunities, both of which are expected to reduce potentially high rates of employee turnover. The plan projects a town population of 1,780 people by 1980, but this figure has already been surpassed, due to the presence of temporary construction personnel. Thus, various estimates of facility needs based on that figure will have to be revised upward. However, population projections for Colstrip are different in the environmental impact analysis conducted by the Westinghouse Corporation (Westinghouse 1973). According to that study, assuming construction of Units 1 and 2, Colstrip's 1974 population was projected at 2,697; and assuming construction of all four units, the town's 1974 population was projected to reach 3,350. According to a Western Energy official, the July 1974 population is mid-way between the Ken R. White and Westinghouse projections, at approximately 2,000 residents. Western Energy officials plan to monitor population growth, primarily to anticipate housing needs and also to provide the school district with demographic information pertinent to school planning needs. In order to adjust to unforeseen alterations in the population growth rate, future residential construction is planned in separate pockets surrounded by open space, allowing physical growth to occur in one or several areas at a time, depending on demand. Other areas covered by the Colstrip Plan--recreation, schools, water facilities--are discussed in the respective categories of this summary report.

b. Forsyth

A comprehensive study of Forsyth's water system has been completed by Morrison-Maierle Inc. (1972), a Billings consulting firm. Recommendations from this study were presented in Section 10.2.3.3. under Municipal Services. No additional exclusively city-sponsored formal planning activity is underway at this time. However, a Rosebud County Planning Board was created recently, with the former County Extension Agent assuming the position of county planning coordinator. The Board has applied to the State Division of Planning for a federal "701" planning grant to finance preparation of a comprehensive county plan./32

c. Lame Deer

More pre-development planning activities need to be initiated by the tribal council; dialogue among tribal members about priorities is especially needed. So far no land-use planning agency designed to control future development activities has been created by the tribal council. Economic planning activities are handled by tribal member George Hiwalker, who manages the Economic Development Administration-supported Economic Development Office in Lame



THE PLAN FOR COLSTRIP, MONTANA

Source: The Plan for Colstrip, Montana
prepared by the Ken R. White Company
Denver, Colorado, December 1972.

FIGURE 10-53

Deer. The Tourism and Recreation Office, financed by tribal funds, is responsible for some planning and programming, mostly of tourist attractions and facilities needed for special events.

B. Quasi-Public and Private-Existing Housing, Commercial Services, and Churches

The private sector of an economy located near coal development activities can yield some valuable insights into the social and economic effects of that development. This study reviewed the situation in housing, commercial services, and churches, primarily in the Forsyth area. Special attention was focused on possible geographical population distribution effects of coal development. Further study of distribution effects is essential if the full socio-economic impacts of coal development are to be evaluated.

This study discusses problems beyond the relatively short-term impacts of coal development. Respondents reflected a distinctly short-term perspective, a perspective that the decision-maker must overcome if the entire cost-benefit pattern of coal development and long-run socio-economic conditions are to receive highest priority.

The status of the supposed "baseline" needs some explanation at the outset. Forsyth and the surrounding area are already impacted by coal development. They have been since mining activity began in 1968 and coal-related construction began in earnest during the summer of 1972./33 For this reason, the base data offered in this study have a built-in bias that is not easily segregated. It would have been ideal to have research efforts begin in advance of any significant coal development in the area. However, since this was not possible, it must simply be noted that the condition of the baseline has already been influenced by rapid, large-scale changes of a type similar to the prospective changes being assessed in the study. Firm base data are difficult to secure. Attributing cause-and-effect relationships is likewise difficult. Notwithstanding these difficulties, we have made an effort to distinguish the pre-study impacts.

Several approaches to data collection were utilized in this study. Generally, those individuals thought to have a working knowledge of, or interest in, coal development were contacted, and then asked to supply additional sources. To insure that we were not retracing the steps of previous research efforts or that we were not securing data from closelyknit circles of respondents, random citizen interviews were also conducted. The data from these interviews were found not to vary markedly from the more selective approach. Finally, although directly relevant documents were almost non-existent, those which could be located were used. For example, files from Action for Eastern Montana, the county planning office, and the county assessor's office were used.

1. Housing

a. Quantity of Housing

i. Forsyth

According to a housing map drawn this summer by the Action for Eastern Montana office, there are approximately 598 housing units in the town of Forsyth. Approximately 580 of these are single-family residences, seven are dual-family residences, and eleven are apartments. These figures are approximate since it was not possible to determine how many apartments may be located within single-family residences. A count from the Action for Eastern Montana map also revealed that some 167 mobile homes were currently occupied in, or near, the town of Forsyth./34

1970 Census Data reveal as follows:

TABLE 10-82

Forsyth, Occupied Housing Units and Motel Units

FORSYTH	
Population	1873
Occupied Housing Units (incl. apts., motels, etc.)	768
Persons in Occupied Housing Units	1842
Owning	1298
Renting	544

Source: 1970 Census, Farmer's Home Administration Data Sheets.

The quantity of housing in the Forsyth area has been influenced by a variety of recent developments, including coal development. The right-of-way for Interstate 90 resulted in the condemnation and removal of 20 to 25 houses. Some of these were transported to existing building sites within the community. This reduced the ability of the town to increase the total amount of housing since it decreased the number of existing building sites. In other cases, residents moved into existing housing units.

According to one utility source, housing starts--based on utility hookups--since 1968 are as follows:

TABLE 10-83

Forsyth--Housing Starts

Year	Starts	Year	Starts
1968	5	1972	11
1969	8	1973	20 (incl. apts.)
1970	11	1974 (to July 1)	8
1971	18		

Others interviewed felt that these figures might be conservative.

Forsyth residents feel immediate needs for complexes and rental units for temporary residents, more units for the elderly, and more units for people on low or fixed incomes. The problem in providing new housing is that people in the community are somewhat reluctant to take the financial risk as they feel the construction boom is temporary, perhaps five to ten years; and a number think that new housing units in Colstrip will remove a great deal of the housing pressure from Forsyth. Federally funded units were suggested as a possibility, but with little enthusiam.

ii. Colstrip/35

Colstrip has 62 older houses which were sold by the Northern Pacific Railroad in 1968 to Western Energy (a wholly-owned subsidiary of MPC) (see Figure 10-54). In 1972, Western Energy built ten houses. In 1973, the company built nine fourplexes (36 units). Western Energy started 20 houses in 1973 and finished them in 1974 (see Figure 10-55).

Colstrip has 128 units of mobile homes which will be one-third of the total housing in the town of Colstrip (not counting construction camps) when the remainder of the housing is completed. In addition, a new forty-unit trailer park is being established south of the center of town. The lots in this park are of sufficient size to accommodate double-wide mobile homes (see Figure 10-56).

b. Quality of Housing

i. Forsyth

In October of 1973, a Forsyth housing quality survey (for single-family residences in and around Forsyth) was completed. The results of the study, covering 615 units, are tabulated below. A significant clustering of below-average housing is indicated.

TABLE 10-84
Forsyth—Housing Quality Survey (Storm 1974)

Excellent	Very Good	Good	Average
0	0	16	162

Below Average	Fair	Poor	Sub-Standard
247	136	30	24

According to the Action for Eastern Montana office, this pattern of housing quality roughly compares to the remainder of southeastern Montana.

ii. Colstrip

The quality of new housing, designed by Drake Gustafson of Billings, is apparently good. The construction techniques are contemporary. Buildings are well insulated, and heated by electricity. Air conditioning is available, at the renter's expense. Space will ultimately be provided for gardens, according to plans.

The overall structural quality of the older houses in Colstrip is poor. Many units need painting or repair work. However, the older part of town does have trees and yards.

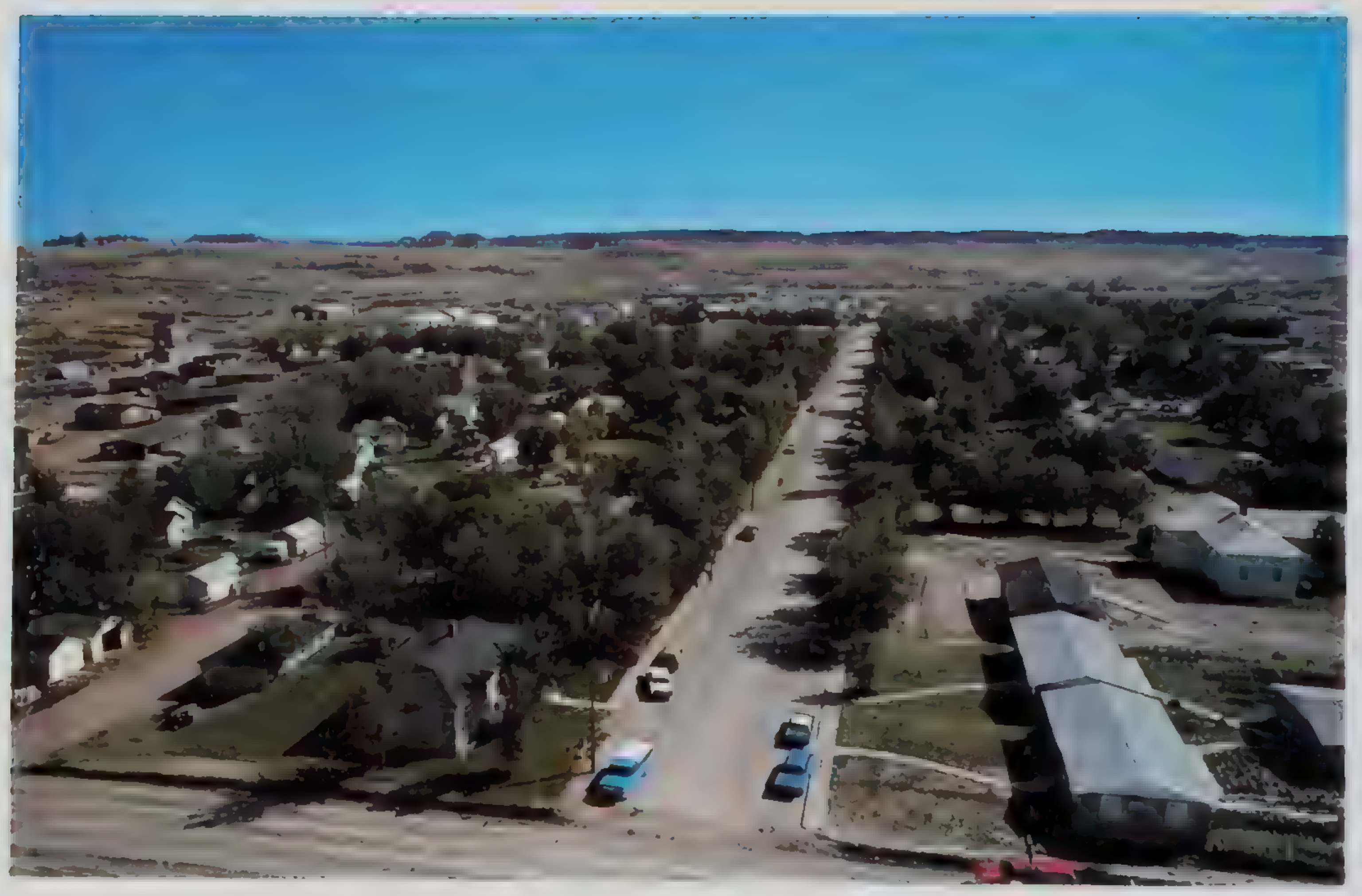
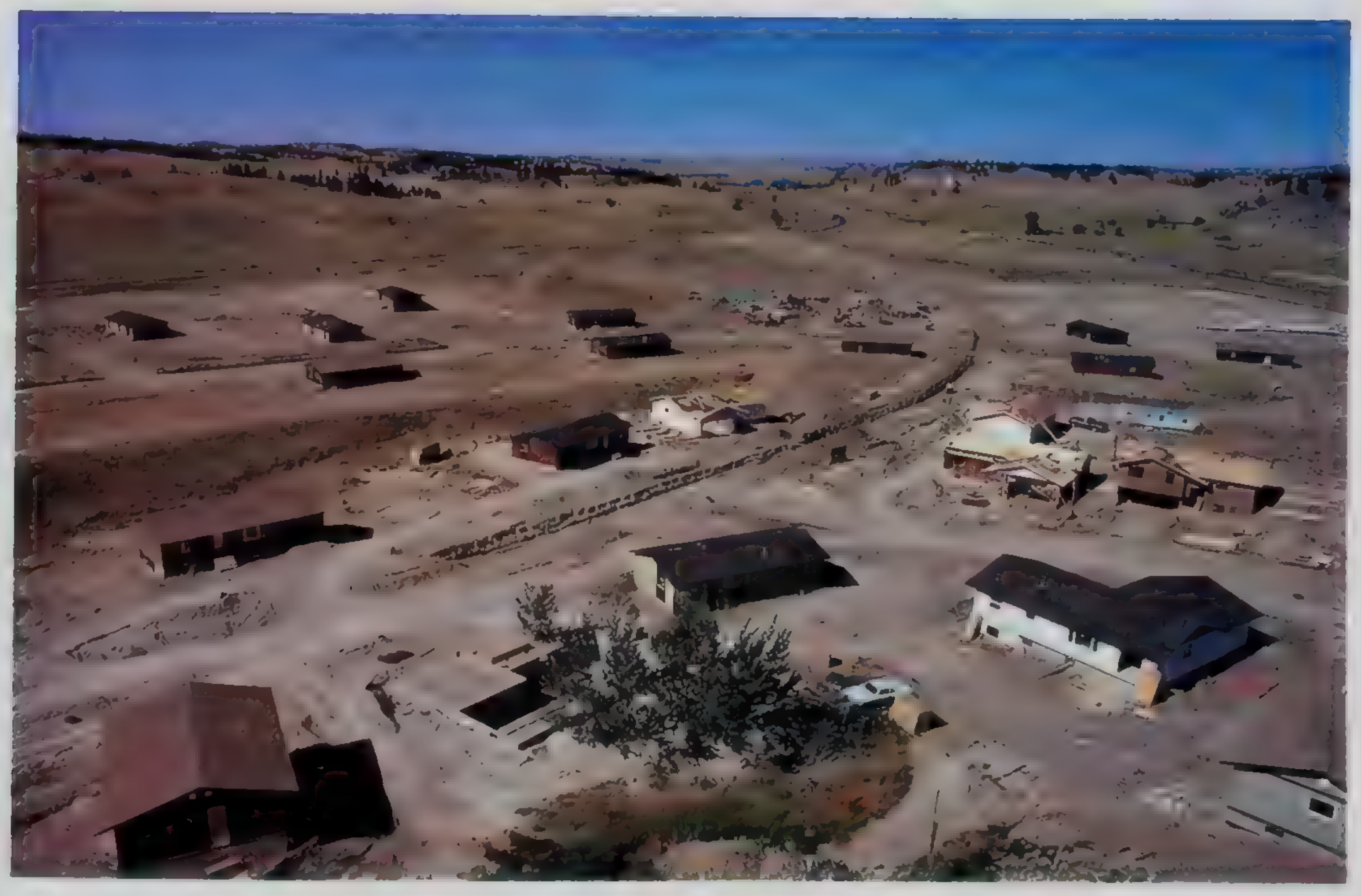


Figure 10-54

Old part of Colstrip

Figure 10-55

New Housing in Colstrip



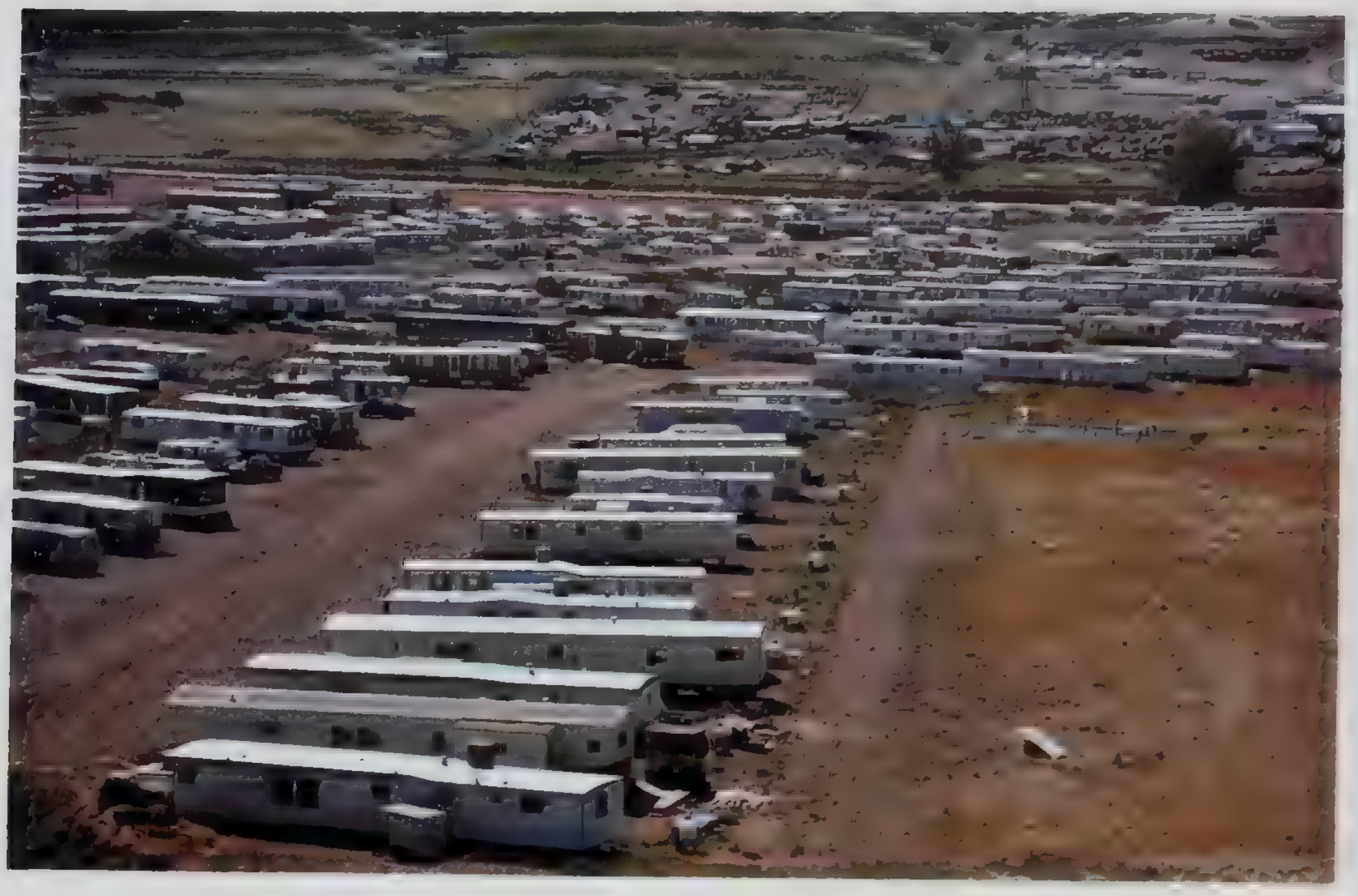
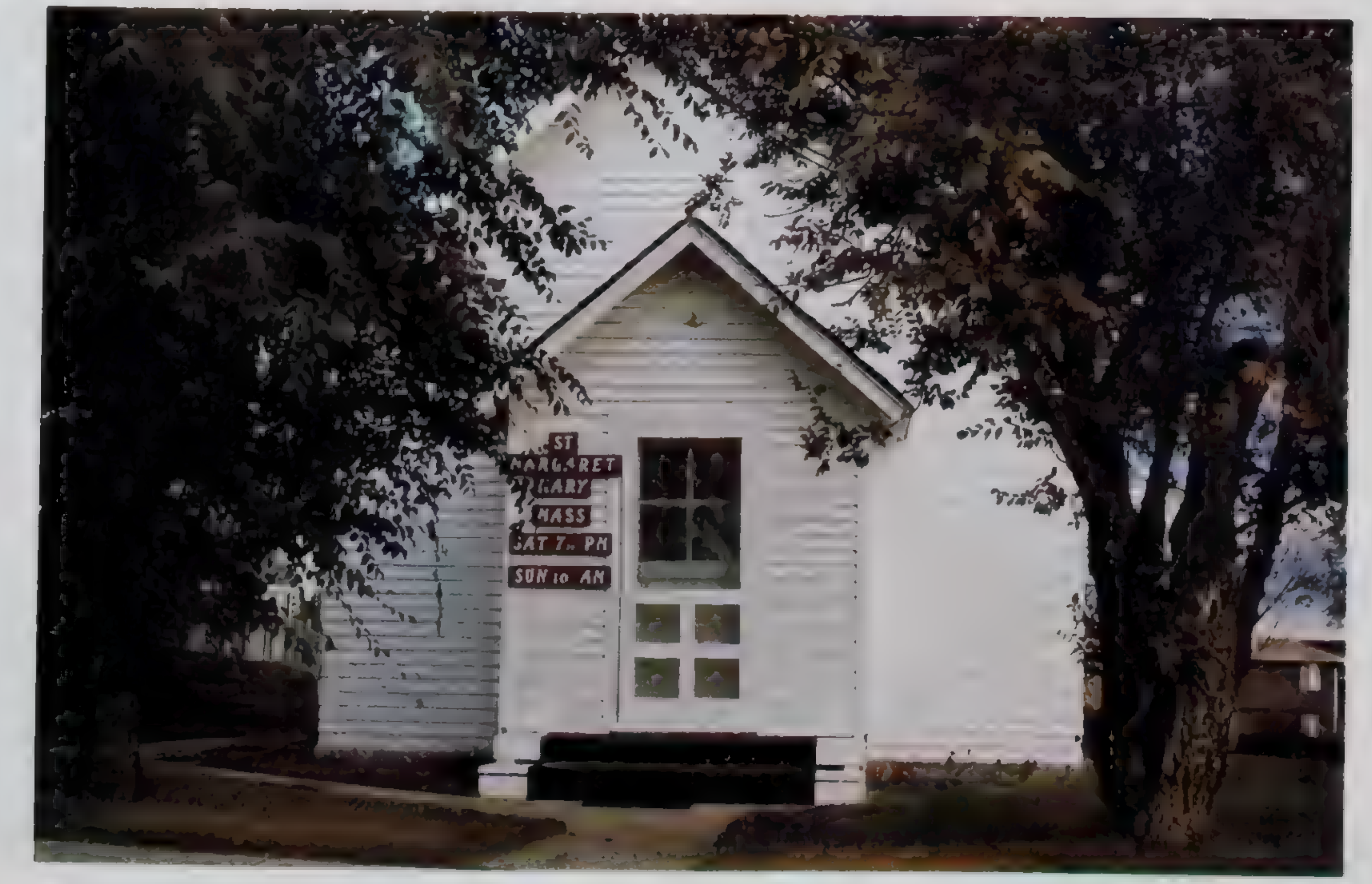


Figure 10-56

Trailer Lots
at Colstrip

Figure 10-57

The Catholic Church
at Colstrip



Location of housing at this time presents some problems. An artificial "caste system" is being created because of the separation of the construction workers from the rest of the inhabitants (Institute for Social Science Research 1974). Thereby, the construction workers experience a comaratively lower quality of living conditions (see Section 10.2.3.2.).

The basic attitude of Western Energy officials is that the town will catch up to the needs soon. Shortcomings are seen as being temporary and not serious. The boom is viewed as short-lived, and the problems are felt to be solvable when a leveling occurs.

c. Price of Housing

i. Forsyth

The price of housing in the study area has increased rapidly over the last few years. For example, one home which sold in 1970 for $12,500 was reportedly sold last year at $19,500. This year it changed hands again at $24,000 (almost doubling in value in less than five years). Four apartments were built in 1968 for $36,000. Two years ago, they were sold for $55,000; and, last year the sale price was $64,000. Other examples were given the reviewers indicating that the price of older homes in Forsyth has doubled in the last five years.

From a sample of 226 rental units, an April 1974, Action for Eastern Montana (AEM) phone survey found the following:

TABLE 10-85
Forsyth--Rental Incidence

Rent (monthly)	Number of Units
Under $40	23
$40 - 59	85
$60 - 79	81
$80 - 99	14
$100 - 199	5
$200 - 299	1
No cash rent	17
TOTAL	226

Information from the AEM office also indicates that rent for homes and trailer space has increased 25 to 50%.

Land values have shown a sometimes dramatic increase also. Several examples were cited in a recent AEM report:

1973 values increased in 1974
from $750 to $1800;
from $500 to $1350;
from $500 to $1120; and
from $ 25 to $ 220

The first example resulted in a property tax increase of $24.35 (Meissner 1974).

Lot prices have also increased. Lots that had risen to $800-$900 from a price of $300-$400 a few years ago are now selling as high as $2500 (50' x 141' standard lot). One individual was astonished when the valuation of his town lots jumped from $800 to $5700 in one year. Taxes on vacant lots were cited by a local realtor to have increased fivefold to tenfold in the past year.

An AEM report prepared by Tom Meissner also cited house rental previously between $85 and $90 increasing to $140 and $150. Apartments now renting for $95 to $120 used to rent for $50 to $60 (Meissner 1974).

Although as the above indicates, there has been some activity in the housing market, the Farmer's Home Administration reports that only four housing loans have been approved since July of 1973, with perhaps two or three currently pending. Part of the reason for this low level of housing loans is the FHA requirement that persons with adjusted gross incomes in excess of a certain amount are not eligible for FHA loans. That income ceiling has recently been increased in two steps. On July 1, 1973, the maximum was $9,500. It was raised on December 1, 1973, to $10,500 and on May 1, 1974, to $12,700. Nearly all of the coal-related employees moving into the area have incomes higher than the FHA maximum. Another reason for the small number of FHA loans may be the prohibition on utilizing those loans for trailer houses and mobile homes. Also, those most likely to need FHA assistance may have yet to shift from their increasingly expensive residences, as they may eventually have to (Section 10.2.3.2.).

Unfortunately, during the study, we were not able to determine the relationship between these price fluctuations and residents' ability to pay. Accordingly, the existence of distribution effects stemming from price increases is not quantifiable at this time, though it is predictable: no doubt, with increases in housing prices, taxes, and rentals, those on low or fixed incomes will pay a larger portion of their disposable income on housing-related expenses.

1970 Census figures on income and unit ownership, when compared to similar figures for later years, including general housing-related costs and income distribution data, could permit some rough quantification of distribution effects. The 1970 figures (a sample of 371 units in Forsyth) are:

TABLE 10-86

Forsyth—Unit/Adjusted Gross Income Sample

Family Adjusted Gross Income	Number of Units
Under $5,000	65
5,000 - 9,999	137
10,000 - 14,999	85
15,000 - 19,999	45
20,000 - 24,999	21
25,000 - 34,999	17
35,000 - 49,999	1
TOTAL	371

Source: Action for Eastern Montana, Forsyth.

ii. Colstrip

Western Energy calculates rents with a formula based on the original price of construction. For example, rent for a three-bedroom unit is $210 a month, plus utilities. The cost to build the unit was $30,000 (White 1974). Air conditioning costs an additional five dollars a month. Older homes are rented in the vicinity of $70 and up.

Space rent for trailers at the Burtco Trailer Camp in Colstrip is $40 a month, including water, sewer, garbage, and the trailer space; electricity is extra. An "electricity only" hookup, primarily for campers, is $25 a month. Showers and other facilities are housed in a separate building.

Disenchantment with the increasing price of housing in Colstrip has surfaced recently. The rent for one two-room unit rose from $125 to $139----approximately a 10% increase. According to a Billings Gazette report of August 6, 1974 ("Colstrip Residents Complain") some rents may have increased from $70 to $130 in one year.

An ancillary cost of housing--cited by the Billings Gazette --is the area-wide use of propane for heating and cooling. A month's supply of propane is cited at $40 in the summer and as high as $150 in the winter. In the newspaper article, Western Energy is quoted arguing that rents have not risen unexpectedly, and that renters knew there would be increases when improvements such as sidewalks and streets were completed.

d. New Developments in Housing

i. Forsyth

A variety of new development proposals have appeared in recent months. With the existing mobile-home courts full or near capacity, construction of a new trailer court/mobile-home complex has begun southeast of Forsyth up the Slaughterhouse Creek drainage. It currently contains about 35 units and will probably expand. The owners of that trailer court have another site just west of Forsyth which could accommodate perhaps 50 units. Another, somewhat smaller trailer court is being located about five miles west of Forsyth.

The existing apartments in Forsyth are apparently full at this time. Twelve new efficiency apartments are being constructed above a downtown store.

Existing home sites are nearly all occupied, although, according to one source, higher density could yield a sizeable number of lots. Eighty acres of land on the Vassau Ranch southeast of Forsyth are proposed for subdivision into ten-plus acre tracts. Additionally, two subdivisions are being considered just east of Forsyth (one located on 17 acres, the other involving as much as 95 acres).

In the Ashland area, a 320-acre subdivision with ten-to-thirteen-acre tracts is being initiated in what was described by a local official as a fragile area.

ii. Colstrip

The Plan for Colstrip, Montana, for Western Energy (Table 10-87), offers an official company guideline for Colstrip growth through 1980 (Ken R. White Company 1972). The suggested facilities are designed to accommodate a company-projected permanent population of 1780 people.

TABLE 10-87

INCREMENTAL INCREASE OF HOUSEHOLDS AND DWELLING UNITS
Colstrip, Montana

	Population			Households			
Year	Single Persons	Members of Family	Total	Single Total	Family Total	Total Increase	Total
1972	44	726	770	44	186	-	230
1973	61	832	893	61	213	44	274
1974	91	1517	1608	91	321	138	412
1975	113	1753	1866	113	449	150	562
1976	106	1738	1844	106	445	-11	551
1978	98	1683	1781	98	431	-22	529
1980	98	1683	1781	98	431	0	529

Ken R. White Company 1972

TABLE 10-87 (cont.)

INCREMENTAL INCREASE OF HOUSEHOLDS AND DWELLING UNITS
Colstrip, Montana

Dwelling Units by Type

Year	Married Family Increase[1]	Married Family Total	Single Family Increase	Single Family Total	Mobile Home Increase	Mobile Home Total	Total Unit Increase	Total
1972	-	38	-	64	-	128	-	230
1973	8	46	27	91	-	128	35	265
1974	15	61	108	199	-	128	123	388
1975	22	83	74	273	-	128	96	434
1976	12	95	0	273	-	128	12	496
1978	0	95	0	273	-	128	0	496
1980	0	95	0	273	-	128	0	496

[1] Based on 50% of single households living alone and 50% sharing a dwelling unit.

Ken R. White Company 1972

Approximately 60 acres are planned for single-family residences, 16 acres for multi-family residences and 24 acres for mobile-home residences. The single-family homes will be in three separate areas; the apartments will be southwest of and adjacent to the existing town, and the new mobile-home park will establish 70 spaces south of the existing mobile-home park.

At this time, construction of three eight-plexes has begun. Thus, the total number of housing units existing in Colstrip is 256. In addition, 64 are under construction and 29 of those are being custom-built for the occupants.

2. Commercial Services

a. Quantity of Services

i. Forsyth

The town of Forsyth provides the fairly typical range of commercial services found in other small rural towns: two grocery stores, one store bakery, seven motels, three hotels, six restaurants four clothing stores, two automotive sales and one automotive repair business, numerous bars and service stations, a liquor store, a furniture store, one funeral home, three hardware stores, two barber shops, five hairdressers, one bank, one pharmacy, two contractors, utilities, telephone service, one appliance shop, two farm-supply businesses, three doctors, one dentist, one chiropractor, four attorneys, and a number of other business establishments. Most of these services are available in the central business district.

In general, residents seem reasonably satisfied with the existing range of services. The only gaps complained of by residents were an insufficient selection in shoe and apparel shops; the lack of a fancy restaurant; and insufficient professional services (legal, dental, and medical).

There has been a pronounced increase in recent years in the level of commercial activity. This is especially reflected in the inventory and sales increases cited by respondents.

A large business in Forsyth which handles apparel and other items has, in recent years, expanded its inventory to include work boots and clothing for workers. The store experienced a 58% increase in sales in 1972-3 and has had over an 80% increase thus far in 1973-4. The size of the store was doubled in June of 1974.

A small, local pharmacy in Forsyth has increased its inventory 50% in the last two years. The owner attributes this entirely to coal development.

The largest grocery store in Forsyth has been expanding steadily for 30 years because of the general economic conditions. It has changed buildings twice and recently moved into a new building several times larger than the old one. Due to the last three years' influx of people and industry, the inventory has increased three and one-half times.

A small radio and television service has changed the type of business service offered. As service demands are expanding, the owner is phasing out appliances and working full-time in the service area. The recent, continuing influx of people means there are more television sets to repair, and technicians are in demand. It is interesting to note that this business is not making a transition to a larger size to meet the demand. Rather, a serviceman who was working at this radio and television service previously is now setting up his own business in Forsyth. The attitude of the present owner is that there is plenty of business for all.

A medium-sized clothing and gift business in Forsyth is increasing its clothing inventory, where there is a greater demand, and is holding steady on gift items. At this time, the owner is considering the possibility of taking on another line of clothing, but has to consider the space problem since the store is fairly small. The owner is also carrying more items that appeal to high-school-aged people and young adults.

A medium-sized family motorcycle sales and repair business in Forsyth has experienced business increases every year since it started business in 1963, due to the increasing popularity of its product. Sales are increasing at a higher rate now because of the heightened demand from the influx of new people. In 1963, only four bikes were sold as compared to present sales of over 100 a year.

The local bank has likewise displayed growth. Deposits are up 60% in the last five years. Twenty-five percent more space has been added. Remote teller windows will be installed to handle the payday and other rush-banking business.

The local golf course, a community-built recreation facility, has increased its membership from 140 (mostly social, non-playing members) to 175 in the last couple of years. In 1973, 1531 green fees were purchased. The 1974 figures may triple the 1973 figures.

Increased commercial activity is also indicated by data secured from the County Assessor's office, shown in Table 10-88. The number of taxable snowmobiles in the county has more than tripled since 1971. Watercraft have quadrupled since 1966. Motorcycles have nearly tripled since 1966.

TABLE 10-88

Taxable Recreational Vehicles in Rosebud County

Year	Snowmobiles	Watercraft	Motorcycles
1966	NA	36	63
1967	NA	32	57
1971	25	56	95
1972	52	98	158
1973	57	113	161
1974	86	129	NA

Whether the increase in these particular categories of commercial services has produced external effects is not known, nor is it known whether these figures indicate an income-distribution effect of leisure time.

ii. Colstrip

Commercial services of any kind are limited in the Colstrip area. A new doctor in Forsyth travels to Colstrip one evening a week. There are also a restaurant, a sundry and grocery business, a motel, and a snack bar. A small fountain, located in the school for a number of years, is apparently being closed due to demands for increased space in the school. Apparently, most of Colstrip residents' commercial activity occurs elsewhere. A good deal takes place in Forsyth, where businessmen have expanded to meet this heightened demand. However, new commercial construction is underway at Colstrip, and could, when completed, significantly reduce the purchases in Forsyth.

A major shopping center will be completed in 1975 (see Figure 10-58). As planned, it will contain a grocery store, a drug and hardware store, a general merchandise shop, offices, medical facilities, a Post Office, and spaces for a laundromat, a beauty parlor, and a barber shop (see Figure 10-59). Additional space will be available if expansion is necessary. The town also plans to have a service station, a small motel, a golf course, and a restaurant.

b. Quality of Services

i. Forsyth

Several changes were noted in the quality of Forsyth's commercial services. The increased inventories provide a greater selection of items. The store renovations may have improved the shopping atmosphere for some. Increased congestion in the downtown area has produced some disenchantment, however. A heightened rush atmosphere has depersonalized the commercial-services sector to an unkown extent and has probably reduced the level of sociability—to some, an important quality in commercial service.

On balance, it is difficult to establish whether the net effects on the commercial service sector are beneficial or adverse, since there appears to be no generally-accepted methodology for assessing qualitative changes in commercial services.

c. Price of Services

To determine the comparative price of staples, Table 10-89 was compiled from grocery stores in Bozeman, Billings, Forsyth, and Miles City.

From the table, it appears that food prices in Forsyth are comparable to other cities in eastern Montana. From personal experience, the reviewers found motel and restaurant prices roughly comparable to those in Billings and Bozeman. Whether the situation holds for other commercial services and whether it will remain throughout the boom is undetermined.

3. Churches

a. Forsyth

Forsyth has eight formal church groups: Presbyterian, Catholic, Methodist, Babtist, Lutheran, Episcopal, Pentecostal, and Christian Scientist.

The United Prebyterian Church has a full-time minister, a half-time secretary, and numerous volunteers. The membership is about 320, with Sunday attendance averaging about 100. The Sunday School is attended by 70 to 100 children.

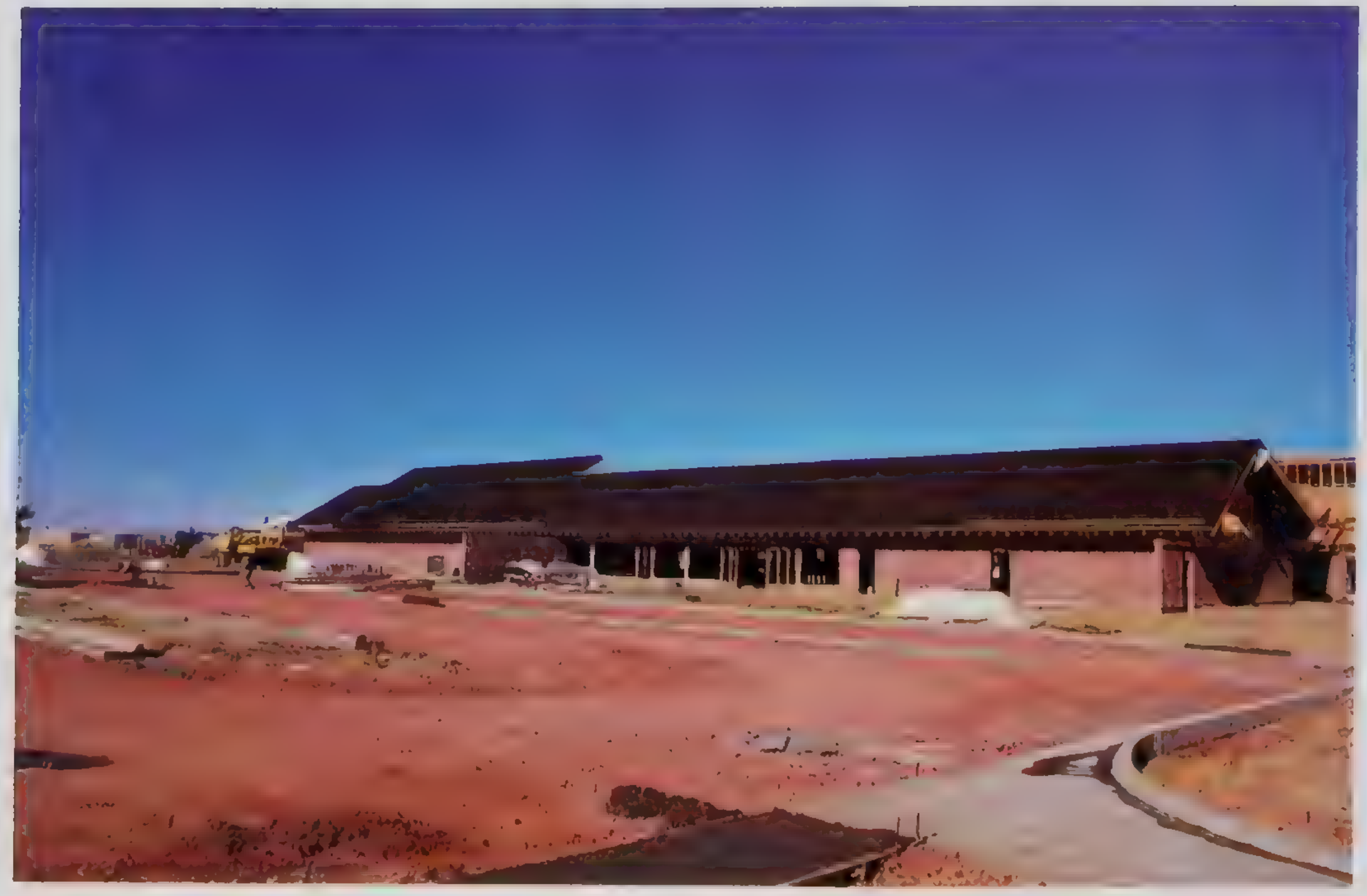


Figure 10-58

Colstrip shopping center under construction

Figure 10-59

Colstrip barber shop and beauty parlor

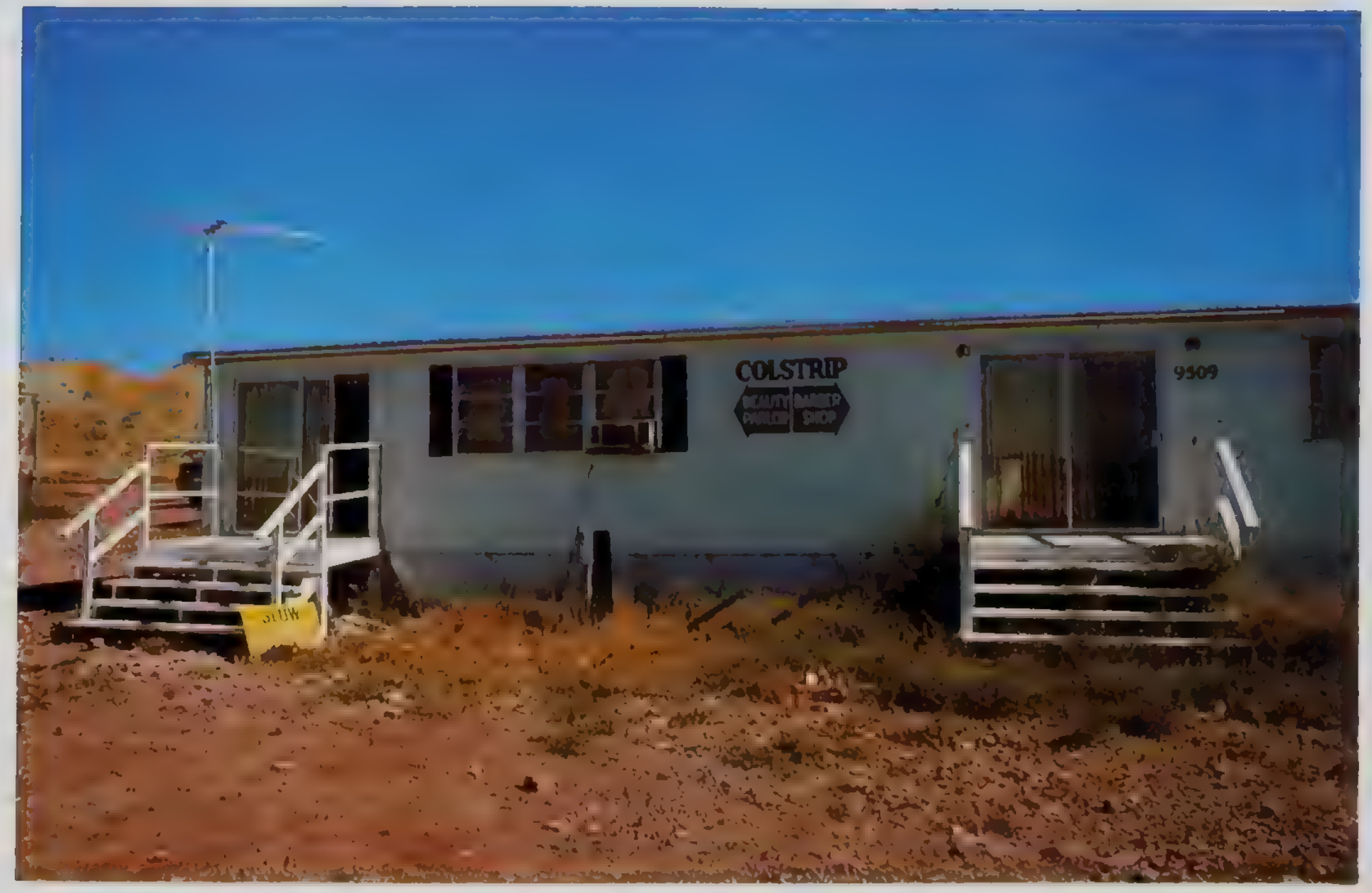


TABLE 10-89

COMPARATIVE FOOD PRICES
(from the week of August 19, 1974)

Price				
Forsyth	Miles City	Billings	Bozeman	Item Description
.85	.69	.89	.79	1 lb. butter
.66	.53	.69	.69	1 lb. margarine
.85	.84	.84	.84	½ gal. regular milk
1.84	.89	1.84	1.84	5 lb. sugar
1.05	1.09	.89	1.07	5 lb. enriched flour
1.98	2.15	1.75	1.95	10 lb. all-purpose enriched flour
.60	.79	.62	.62	AA large--1 doz. eggs
.59	.59	.59	.56	Sandwich bread (white)
.59	.59	.59	.56	Enriched white bread
.59	.55		.56	Wheat bread
2.06	2.29	2.29	2.44	Dog food
.27	.28	.30	.30	Cheddar cheese soup
.61	.59	.59	.59	Tuna (small can)
.89	.79	.79	.79	1 lb hamburger (ground beef
1.29	.79	1.09	1.09	1 lb ground round
2.19	1.79	2.29	2.39	1 lb. T-bone

Membership is increasing, and the pastor described an 18% growth in 1973.

The Immaculate Conception Catholic Church has a resident minister, numerous volunteers, and a membership of approximately 100 families.

The Wesleyan Church has a resident minister, some voluntary help, a membership of 80 persons, and approximately 30 children in Sunday School. The membership is increasing; Sunday School attendance has doubled in just a few years.

The First Baptist Church has a resident minister, volunteer help, a membership of 75, and 50 children in Sunday School. Again, growth was noted because of a doubling of Sunday School attendance in a small number of years.

The Concordia Lutheran Church also has a resident minister; the Ascension Episcopal Church has a minister one day a week and on Sunday from Miles City; and the Church of Latter Day Saints has a coordinator from Hysham.

All the churches in Forsyth have experienced growth in recent years, exemplified by increased attendance and increased financial contributions. No churches have closed down, although the Catholic school was phased out because of financial difficulties.

Pastors generally feel that the religious climate is good in Forsyth and not much different from other communities.

Services beyond Sunday morning worship include a limited amount of marriage counseling. Some churches share in providing church services at the nursing home. Most have some kind of Bible-study group, and some have youth groups and women's organizations.

The churches in Forsyth are experiencing an influx of young people, especially young adults and married couples with children. The result is a doubling and tripling of Sunday School classes over the last six to ten years. Pastors attribute this growth to a number of causes, including younger ministers, greater efforts and programs to attract young people, more young people staying and taking jobs in the community, and the influx of temporary construction families in the community.

In spite of this increase, however, some pastors think a smaller percentage of the community is actually attending church, and the full potential has by no means been reached. The smaller percentage is attributed to increasing disenchantment of young people with church and to greater incomes which allow the time and necessary finances for people to use the weekends for recreational trips.

One pastor felt that there was now a drop in the attendance of the middle-age adult group, but could offer no explanation.

Some pastors see positive changes taking place in the community, brought about by coal development. Most importantly, they feel, more young people are staying in the community. Previously, most Forsyth youth wanted to leave town. The pastors also notice a better attitude among townspeople toward the community—a greater sense of civic pride.

New problems which some pastors have become aware of and attribute to coal development include the following:

1) An inability of some people to handle greater amounts of money;

2) Too little incentive to get further schooling and training because of the availability of jobs and money;

3) Unsteady economic conditions which result in high wages for a time, followed by strikes and food stamps;

4) High cost of living due to the construction activities, which in a few cases has caused people to move away because they could not afford to stay; and

5) Temporary residents and minorities in the area, which the churches have not adequately contacted.

Most pastors do not seem alarmed at the possibility of a greater level of coal/energy development. One pastor thought that growth might present some problems for the community in providing services, but that the difficulties would not be great for businesses and churches. Several thought the most significant coal-related problems would be in Colstrip rather than Forsyth. Some thought that the social problems are simply human problems which exist in all communities and that Forsyth would be no worse than other communities. Most thought there were no great gaps in church services or social services which churches should fill. For example, marriage counseling is already available, but for the most part, unused. Some illegal drug use is present, but it is felt that it is not serious enough to require a new program. An Alcoholics Anonymous meets in town and is available for needs in that area. (Furthermore, the evangelical churches preach abstinence from alcohol, do not find the situation serious within their congregations, and do not feel much responsibility beyond their congregation.)

As far as future ideals are concerned, most pastors would like to see increased participation in church activities, more cooperation among churches, and more activities for youth and young adults.

Most pastors agreed that a conflict exists among the churches in Forsyth because of a split in doctrinal approach—evangelical and modernistic. This schism has existed for some time and is apparently not related to coal development. Most pastors feel it is not very damaging to the community and is mostly a matter of different churches pursuing divergent programs and interests.

Forsyth residents who were asked about church facilities and programs largely reflect the easy-going mood of the pastors. The residents believe the churches are adequately fulfilling the needs of the community and are average or above average in comparison to other communities. Extracurricular programs are felt to be adequate. Few people call for new programs or directions.

b. Colstrip

Colstrip has three churches and a pending proposal for another.

The Community Church is mixed denomination, has traditionally drawn membership from a broad geographical area, and owns its own land which Northern Pacific donated before it sold Colstrip to Western Energy.

The Lutherans split from the Community Church during the past year. The Lutheran minister is presently part-time, and a full-time one is desired. The Lutherans have their own church, and the site is leased for a nominal amount from Western Energy.

The Catholic Church (see Figure 10-57) in Colstrip has a part-time minister from the St. Labre Mission at Ashland. A full-time minister is also sought here.

The Mormons are applying to Western Energy for the purpose of building a Colstrip church.

10.2.3.4. The Structure of the Rosebud County Economy

Historically the Rosebud County economy has been dominated by agriculture. Agricultural earnings have made up close to 50% of total county earnings over much of the past 40 years. The share of earnings attributable to agriculture dropped sharply in the mid-1960's, but by 1972 agricultural earnings were up to 34% of the county total. The absoulute amount of agricultural earnings had increased, but not as rapidly as other sectors of the economy, particularly mining, services and government./36

The relative share of Rosebud County earnings for each of the major economic sectors is shown in Figure 10-60. Dollar amounts are shown in Table 10-90 for both personal income and earnings. Personal income includes all non-corporate income (wages, salaries, partnership income, interest, transfer payments), whereas earnings exclude transfer payments and property income.

A. Rosebud County Growth 1920 - 1972

1. Personal and Per Capita Income

Figure 10-61 shows that Rosebud County population has been slowly declining from 1920 to 1972, while personal incomes have been growing at modest rates. Table 10-91 indicates that from 1929 to 1970 Rosebud County personal incomes grew from $3,194,000 to $19,094,000, or 497.8% in 41 years. On the other hand, the county's population declined from 8,002 in 1920 to 6,032 in 1970, a 24.6% decline over 50 years. Combining the income increase with the population decrease indicates that per capita personal income increased from approximately $431 in 1929 to $3,165 in 1970 and $3,780 in 1972.

While Rosebud County personal income has grown by some 497.8% from 1929 to 1970, Montana's personal income grew by 672.6%, and the nationwide personal income grew by 836.5%. Thus, over the same 41 year period, total personal income has grown more slowly in Rosebud County than in Montana or the United States as a whole. However, this differential is in total personal income. Converting total personal income to per capita personal income (a better measure of individual welfare), Rosebud County compares very favorably with the rest of the state. Over the 41 year time span (1929-1970), the percentage of increase in Rosebud County per capita income was 23% greater than the corresponding percentage increase in per capita income for the state. Per capita income for Rosebud County in 1970 was $3,165; by 1972 it had climbed to $3,780.

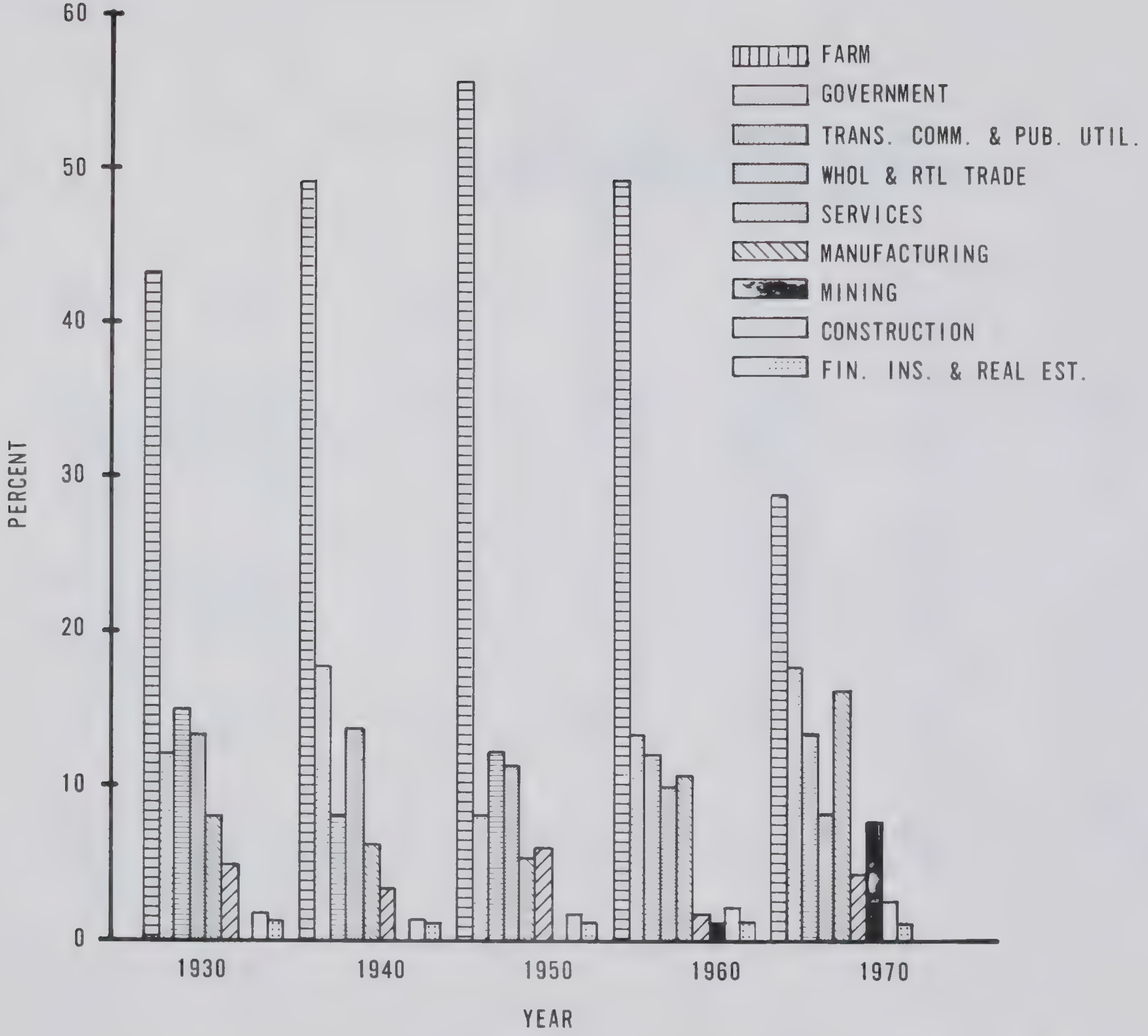
2. Agriculture

The population decline experienced in Rosebud County was a phenomenon common to rural areas throughout the nation in the 1920 to 1970 period. The major industry of these areas, agriculture, has been subject to relatively low prices over the period. The demand for industrial labor has been strong and unit labor prices high. The result was the bidding away of labor from the farm. There have also been large increases in farm labor productivity caused by more capital-intensive, less labor-intensive farm machinery. The net effect of these phenomena has been to make a typical farmer or rancher a large landowner and an efficient, capital-intensive food producer. Agriculture in Rosebud County is no exception.

By 1970 agriculture was emerging with new economic vigor, even with the relatively low prices of that year. With high 1973 agriculture prices resulting from food shortages, agriculture in Rosebud County, as elsewhere, was not only efficient, but its economic influence was reasserted in Rosebud County and Montana as well as in the entire U.S. as the major export sector of our economy.

3. Employment

Rosebud County employment by source for 1967 through 1962 is detailed in Table 10-78. The rise in mining activity in Rosebud County over the last six years is demonstrated. Although the absolute magnitudes are relatively small, mining earnings increased by 990% between 1967 and 1972 (Table 10-90), and employment in mining increased 790% (Table 10- 92). The influence of mining in Rosebud County will continue to grow over the next 20 years.



Rosebud County Earnings by Broad Industrial Sector; 1930–1970
(Percent of Total)

FIGURE 10-60

TABLE 10-90

Personal Income by Major Sources and Earnings by Broad Industrial Sector (In Thousands of Dollars)

	1929	1940	1950	1959	1962	1965
Total Personal Income	3,194	3,325	9,795	12,434	14,241	12,483
Total Wage and Salary Disbursements	1,784	1,531	3,704	NA	NA	NA
Other Labor Income	22	21	80	NA	NA	NA
Proprietors Income	1,060	1,474	4,914	NA	NA	NA
Farm Proprietors Income	668	1,123	4,083	5,434	6,015	1,428
Non-Farm Proprietors Income	392	351	831	930	983	1,052
Property Income	263	185	587	1,152	1,328	1,856
Transfer Payments	75	138	651	951	1,055	1,296
Less Personal Contributions for Social Security Insurance	10	24	141	241	300	374

NA = Not Available

TABLE 10-90 (Cont.)

Personal Income by Major Sources
and Earnings by Broad Industrial Sector
(In Thousands of Dollars)

	1966	1967	1968	1969	1970	1971	1972
Total Personal Income	12,353	13,527	15,456	17,390	19,094	21,067	24,191
Total Wage and Salary Disbursements	NA	NA	8,286	9,239	9,764	11,044	12,332
Other Labor Income	NA	NA	438	525	605	690	816
Proprietors Income	NA	NA	3,231	3,800	4,467	4,836	6,261
Farm Proprietors Income	1,493	NA	2,107	2,641	3,260	3,721	5,121
Nonfarm Proprietors Income	1,085	NA	1,124	1,159	1,207	1,115	1,143
Property Income	1,874	NA	2,233	2,515	2,714	2,876	3,045
Transfer Payments	1,429	NA	1,783	1,911	2,181	2,395	2,478
Less Personal Contributions for Social Security Insurance	417	NA	515	600	637	774	744

NA = Not Available

TABLE 10-90 (Cont.)

Personal Income by Major Sources and Earnings by Broad Industrial Sector (In Thousands of Dollars)

	1929	1940	1950	1959	1962	1965
Total Earnings	2,866	3,026	8,698	10,572	12,158	9,705
Farm Earnings	1,214	1,495	4,782	5,290	5,806	1,193
Government Earnings	344	537	676	1,340	1,795	2,157
Manufacturing	(D)	(D)	(D)	145	75	587
Mining	(D)	(D)	(D)	93	159	1,030
Contract Construction	45	40	168	224	200	434
Transportation, Communication and Public Utilities	461	248	1,060	1,172	1,613	1,425
Wholesale and Retail Trade	384	407	975	1,052	1,107	1,188
Finance, Insurance and Real Estate	34	24	81	122	123	147
Services	237	182	447	1,134	1,280	1,544

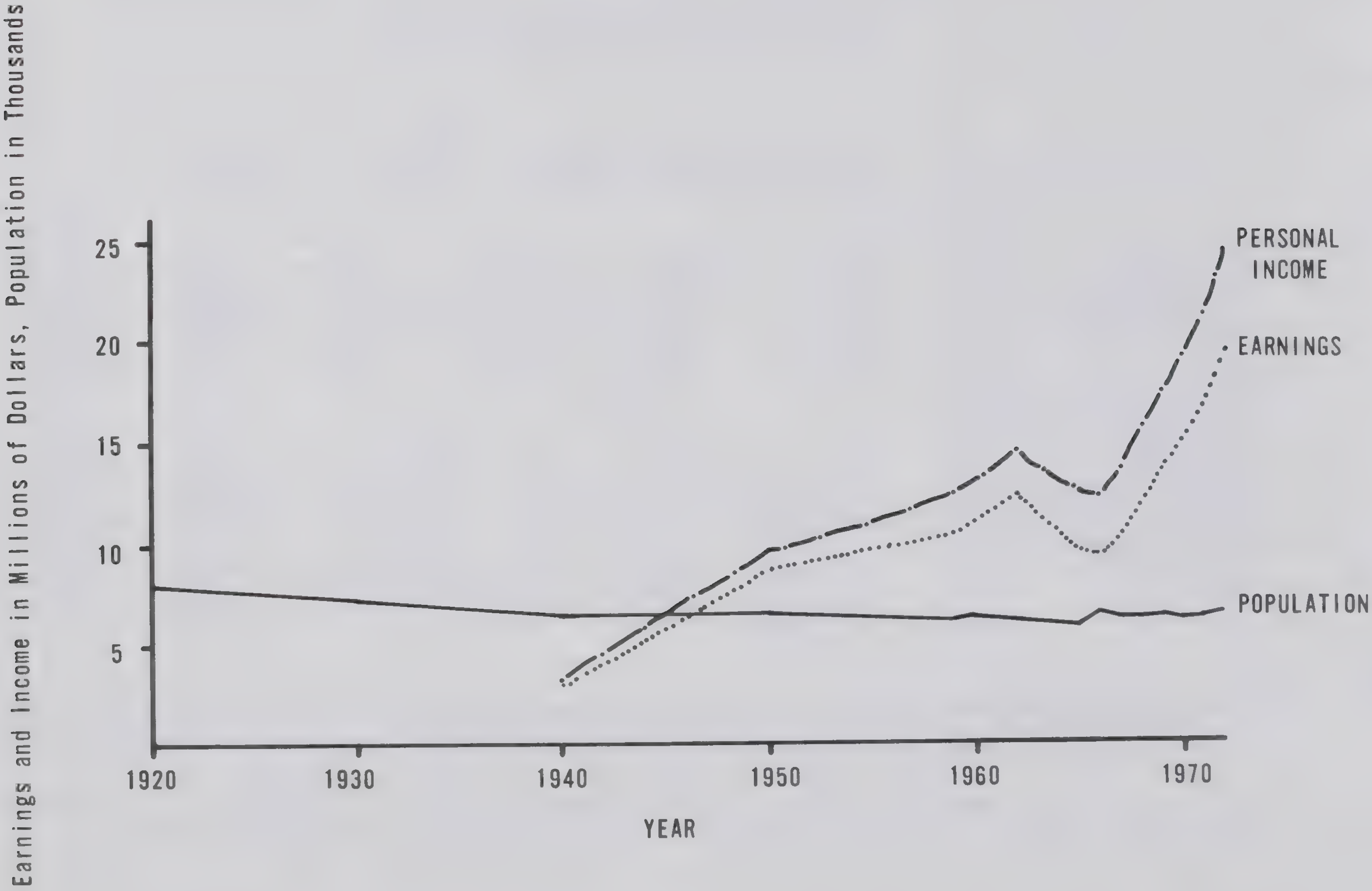
(D) Data Withheld to Avoid Disclosure

TABLE 10-90 (Cont.)

Personal Income by Major Sources and Earnings by Broad Industrial Sector (In Thousands of Dollars)

	1966	1967	1968	1969	1970	1971	1972
Total Earnings	9,467	10,326	11,955	13,564	14,836	16,570	19,412
Farm Earnings	1,387	2,081	3,093	3,859	4,469	5,018	6,532
Government Earnings	2,161	2,251	2,424	2,459	2,594	2,993	3,302
Manufacturing	698	723	758	983	1,116	1,297	1,349
Mining	261	126	148	432	628	893	1,248
Contract Construction	239	281	358	498	325	205	393
Transportation, Communication and Public Utilities	1,532	1,600	1,721	1,839	1,961	2,082	2,204
Wholesale and Retail Trade	1,225	1,286	1,320	1,166	1,233	1,371	1,471
Finance, Insurance and Real Estate	156	156	158	156	148	196	258
Services	1,808	1,822	1,975	2,172	2,362	2,515	2,655

Source: Bureau of Economic Analysis, U.S. Department of Commerce, and Research Information Systems Division, Montana Department of Intergovernmental Relations.



Rosebud County Earnings, Personal Income and Population 1920–1972

FIGURE 10-61

TABLE 10-91

Rosebud County Total Earnings, Personal Income, Employment, Population and Growth Rates, 1920 to 1972

	Earnings (1) (000$)	Personal Income (000$)	Percentage of Change	Employment	Population	Percentage of Change
1920					8002	
1299	2866	3194				
1930					7347	- 8.2
1940	3026	3325	+ 4.1		6477	-11.8
1950	8698	9795	+195.6		6570	+ 1.4
1959	10572	12434	+ 26.9		6100	- 7.2
1960					6187	+ 1.4
1962	12158	14241	+ 14.5		6100	- 1.4
1965	9705	12483	- 12.3		6900	- 3.3
1966	9467	12353	- 1.1		6200	+ 5.1
1967	10326	13527	+ 9.5	2569	6100	- 1.6
1968	11955	15456	+ 14.2	2544	6100	N.C.
1969	13564	17390	+ 12.5	2506	6100	N.C.
1970	14836	19094	+ 9.8	2550	6032	- 1.1
1971	16570	21069	+ 10.3	2782	6100	+ 1.1
1972	19412	24191	+ 14.8	2909	6400	+ 4.9

N.C. No Change

(1), (2) 1929 through 1972 figure is current dollars; no adjustment to reflect price changes.

Source: U.S. Department of Commerce, Bureau of Census; Bureau of Economic Analysis Research and Information Systems Division, Montana Department of Intergovernmental Relations.

TABLE 10-92

Rosebud County Employment by Broad Industrial Sector, 1967 - 1972
(Full and Part Time Wage and Salary Employment Plus Proprietors)

	1967	1968	1969	1970	1971	1972
Total	2,569	2,544	2,506	2,550	2,782	2,909
Total Proprietor	664	663	730	732	737	734
Total Farm Proprietor	431	430	428	423	417	410
Total Non-Farm Proprietor	233	233	302	309	320	324
Wages and Salary Employment	1,905	1,881	1,776	1,818	2,045	2,175
Total Farm Employment	310	267	263	263	286	286
Total Non-Farm Employment	1,595	1,614	1,513	1,555	1,759	1,889
Government	444	445	431	439	455	470
Total Federal	135	131	117	108	111	119
Federal Civilian	135	130	117	108	111	119
Federal Military	1	1	--	--	--	--
State and Local	309	314	314	331	344	351
Private Non-Farm	1,151	1,169	1,082	1,116	1,304	1,419
Manufacturing	168	154	200	213	229	265
Mining	13	19	37	43	79	103
Contract Construction	38	52	55	29	25	39
Transportation, Communication and Public Utilities	205	207	204	207	208	206
Wholesale and Retail Trade	238	256	214	212	238	263
Finance, Insurance and Real Estate	23	21	19	19	25	36
Services	461	454	343	387	495	501
Other	5	6	10	6	5	6

FOOTNOTES

CHAPTER TEN

1. U.S. Department of Commerce 1965; U.S. Department of Commerce no date; U.S. Department of Commerce 1972.

2. The maximum monthly snowfall at Colstrip for the 1941-1970 period was 19" in April, 1955. The maximum 24-hour and monthly snowfalls at Miles City were 28" and 35.3", respectively, in March, 1894.

3. Table 1 in Appendix A4 lists the probability of the occurence of a freeze-free season shorter or longer than the average values given on the map.

4. During their one year of data collection at Colstrip, Super et al. reported the incidence of 307 ft. AGL wind speeds greater than 40 miles per hour to be .32% per year.

5. Fastest mile is the fastest observed one minute wind speed.

6. This is true only as long as the mixing depth exceeds the effective plume height of the pollutant emission sources. When the reverse situation is true, pollutants will tend to remain trapped above the mixing layer so that ground level concentrations will remain low.

7. Appendix A5 lists the AEC criteria and the modified AEC criteria used by Super et al. (1973).

8. Mixing depths were determined from aircraft measurements only to an altitude of 10,000 ft. AGL. Thus mixing depths exceeding 10,000 ft. AFL were reported as 10,000 ft. The above calculated mean maximum mixing depths will therefore be somewhat less than the true values.

9. The Montana one hour SO_2 standard is .25 ppm, not to be exceeded more than once in 4 days.

10. The average value of the change in potential temperature with height $\frac{\Delta\theta}{\Delta z}$, was calculated to be a small negative value (-.0006 $^{\circ}C/m$) for one of the inversion or isothermal layers reported by Super et al. 1973. Since $\frac{\Delta\theta}{\Delta z} < 0$ indicated unstable conditions this case was not considered in the plume rise calculations.

11. For a description of the methodological problems involved in studying community social structures see W. Lloyd Warner et al. Yankee City Series. 5 vol. New Haven: Yale University Press 1941-1959.

12. Figures concerning the effects of population growth occurring in 1973 and 1974, critical years for coal development in this area, are not available as of this writing.

13. It was reported that Montana Power claims to give hiring preference to Montanans, but some local observers question whether this is really so.

14. Neighboring towns are garnering some economic benefits from coal development, notably from the wide-ranging construction workers and from the

small number of disgruntled ranchers who no longer wish to shop in Forsyth. Hardin business men have expected and looked for a boom which has not yet come and are grateful for what business comes their way from the Forsyth area. While its neighboring communities (including Forsyth) have not made such a formally organized effort, Hardin, a near-reservation town, has already made a considerable investment in expanding and modernizing stores in hopes of attracting more business.

15. A local joke is that no landowner in the area wants to be the first to subdivide but a few of them sure would like to be the second.

16. The trailer court for construction workers, referred to as "the ghetto" by some people, is temporary and will be phased out as soon as possible in order to make space for anticipated company installations. Lots here cost between fifteen hundred and two thousand dollars. The other new trailer court, where lots cost five thousand dollars each, and the new houses will be available to the permanent residents of Colstrip when power plant construction ends (it is planned to begin selling off lots and houses in a couple of years). Workers ordinarily bring in their own trailers, but provisions can also be made to lease them from BURTCO, which manages the temporary court for Western Energy.

17. One newcomer independently made this suggestion also, adding landowners as a fourth group.

18. As a group, the businessmen so far appear quite willing to put up with the inconveniences, insecurities, and other social costs of rapid urbanization accompanying population growth. They report viewing such costs as minor annoyances which have not yet struck them as important variables in their lives. Others have apparently chosen to ignore the long-term problems.

19. The technique used for gathering the data is called sociological sampling, so named because it relies heavily upon the natural, social knowledge of people in the study area to assist in quickly locating the most useful and credible information sources. Accordingly, sociological sampling calls for enlisting the direct assistance of local informants in identifying significant social categories in the community and in finding ways of getting in touch with people who are locally thought to be good representatives of these categories. This technique rapidly yields data that is every bit as reliable and valid as that obtained through probability sampling, a noteworthy difference in results being that the latter procedure permits making finer numerical discriminations when comparing categories of responses. For example, sociological sampling may reveal that the great majority of ranchers oppose coal development; but a probability sample would have to be taken if it became necessary to know if this great majority consisted of exactly, say, 82% or 91% of the ranchers. In addition to producing data much faster than probability sampling can, the sociological sampling procedure has the singular advantage of revealing empirically grounded ways of explaining the data. The methodology employed is described in more detail in Appendix H1.

20. On February 6, 1974, Nolan Fandrich, Western Energy's Town Manager at Colstrip reported that

301 employees were commuting to Colstrip from the following towns (the total number commuting from each town is in parentheses): Hardin (4), Forsyth (175), Miles City (74), Roberts (4), Crow Agency (1), Lame Deer (20), Busby (3), Ashland (12), and Billings (8). In addition to these commuting employees, Mr. Fandrich reported that 572 workers were residing at Colstrip.

21. Bechtel is the prime contractor responsible for construction of the generating facilities at Colstrip.

22. In this context, career guidance should include helping Indian people to relate productively with white culture without having to sacrifice their own values.

23. Brian Roat, Supervisor of Fire Prevention and Inspection Section of the State Fire Marshall's Office, is willing to make available the services of his office to advise MPC officials on the improvements needed to adequately protect the safety and property of Colstrip residents. He feels that Colstrip is fortunate that no major fires have occurred there to date.

24. Fire ratings are established by the National Board of Fire Underwriters on the basis of a complex formula which includes a deficiency point analysis of such variables as the water system (including hydrants), fire-fighting equipment, the fire service communications system, and the fire safety control program.

25. Adequacy Standard: 1 Officer: 500 population. (Intermountain Planners and Wirth-Berger Associates 1974).

26. The county has recently authorized funding for employment of a second deputy to work at Colstrip.

27. The Billings Gazette of August 1, 1974 reported that this service will terminate on September 15, 1974, although apparently Amtrak plans to restore daily service next summer. During the winter three-times-a-week service is projected.

28. Adequacy standard: 517.5 gallons per day per person peak day per capita usage plus 15% safety factor (Intermountain Planners and Wirth-Berger Associates 1974). Since the Western Energy Company does not charge for water usage and thus the residents may use more than is normal, this amount may not be sufficient.

29. Intermountain Planners and Wirth-Berger Associates (1974) is the source for adequacy standards used in these calculations. The peak measured daily usage rate in the summer (862.4 gallons per minute) was transformed into an hourly usage rate of 51,744 gallons. The present input rate of treated water into the storage tank is 21,000 gallons per day. Adding a depletion rate of 30,000 gallons per hour used during a fire at the maximum pumping capacity gives a fire depletion rate of 81,744 gallons per hour. This figure was then divided into the maximum water storage capacity (710,000 gallons) in Colstrip to give the number of hours it would take to deplete the water storage tanks during a fire. The figure of 8 hours of fire fighting capability expresses a maximum period of time in which to deplete water tanks. Since water use fluctuates, the average hourly and daily consumption rates are lower than those indicated by peak usage figures.

Thus, fire capability is actually greater than 8 hours and could conceivably be extended to 24 hours.

30. This flow rate is calculated to meet the peak hourly demand for 1995, the design year.

31. The Public Works Director stated in February 1974 that the city had applied for a grant for this amount.

32. A "701" grant is the standard planning program funding grant provided for by the Housing and Urban Development Act.

33. Construction of Colstrip Units 1 and 2 is scheduled for completion in July 1975 and July 1976 respectively. Surface mining at Colstrip resumed in 1968 and started at Peabody in 1968.

34. The Forsyth office of Action for Eastern Montana has prepared and will continually update a map of the housing units in and around Forsyth. That office also intends to do a map of the town of Rosebud.

35. The data in the Colstrip sections of this report were obtained from Don Patterson's interview of Martin White, Colstrip Project Manager, Western Energy Company.

36. The Rosebud government and services sector include the wages and salaries earned by government employees of the Northern Cheyenne Indian Reservation and the earnings of employees of the Northern Cheyenne Tribal Council, a non-profit membership organization (Standard Industrial - Classification Code 86).